SR 179/SR 89A/SR 260 CORRIDOR PROFILE STUDY

SR 179: 1-17 TO SR 89A
SR 89A: SR 179 TO SR 260
SR 260: 89A TO I-17

ADOT WORK TASK NO. MPD 0041-17
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DRAFT REPORT: SOLUTION DEVELOPMENT, EVALUATION, AND PRIORITIZATION

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PREPARED FOR:

ARIZONA DEPARTMENT OF TRANSPORTATION

PREPARED BY:

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Note: Appendices A through D and K are not included. Appendices A through D were provided in the previously submitted Draft Report: Performance and Needs Evaluation. Appendix K will be provided in the Draft Final Report.

ACRONYMS & ABBREVIATIONS

AADT	Average Annual Daily Traffic
ABISS	Arizona Bridge Information and Storage System
ADOT	Arizona Department of Transportation
AGFD	Arizona Game and Fish Department
ASLD	Arizona State Land Department
AZTDM	Arizona Statewide Travel Demand Model
BLM	Bureau of Land Management
BQAZ	Building a Quality Arizona
CCTV	Closed Circuit Television
CR	Cracking Rating
DCR	Design Concept Report
DMS	Dynamic Message Sign
FHWA	Federal Highway Administration
FY	Fiscal Year
HCRS	Highway Condition Reporting System
HERE	Real time traffic conditions database produced by American Digital Cartography Inc.
HPMS	Highway Performance Monitoring System
I-	Interstate
IRI	International Roughness Index
ITS	Intelligent Transportation System
LCCA	Life-Cycle Cost Analysis
LOS	Level of Service
LRTP	Long-Range Transportation Plan
MAP-21	Moving Ahead for Progress in the 21st Century
MP	Milepost
MPD	Multimodal Planning Division
NACOG	Northern Arizona Council of Governments
NB	Northbound
NPV	Net Present Value
OP	Overpass
P2P	Planning-to-Programming
PA	Project Assessment
PARA	Planning Assistance for Rural Areas
PDI	Pavement Distress Index
PES	Performance Effectiveness Score
PSR	Pavement Serviceability Rating
PTI	Planning Time Index
RTP	Regional Transportation Plan
RWIS	Road Weather Information System
SATS	Small Area Transportation Study
SB	Southbound
SERI	Species of Economic and Recreational Importance
SHSP	Strategic Highway Safety Plan
SOV	Single Occupancy Vehicle
SR	State Route
TAC	Technical Advisory Committee
TI	Traffic Interchange
TIP	Transportation Improvement Plan
TPTI	Truck Planning Time Index
TTI	Travel Time Index
TTTI	Truck Travel Time Index
UP	Underpass
USDOT	United States Department of Transportation
V/C	Volume-to-Capacity Ratio
VMT	Vehicle-Miles Travelled
WIM	Weigh-in-Motion

1.0 INTRODUCTION

The Arizona Department of Transportation (ADOT) is the lead agency for this Corridor Profile Study (CPS) of State Route 179 (SR 179)/State Route 89A (SR 89A)/State Route 260 (SR 260) between Junction Interstate 17 (I-17) at Exit 298 and Junction I-17 at Exit 287. The study examines key performance measures relative to the SR 179/SR 89A/SR 260 corridor, and the results of this performance evaluation are used to identify potential strategic improvements. The intent of the corridor profile program, and of ADOT's Planning-to-Programming (P2P) process, is to conduct performance-based planning to identify areas of need and make the most efficient use of available funding to provide an efficient transportation network.

ADOT has already conducted eleven CPS within three separate groupings or rounds.

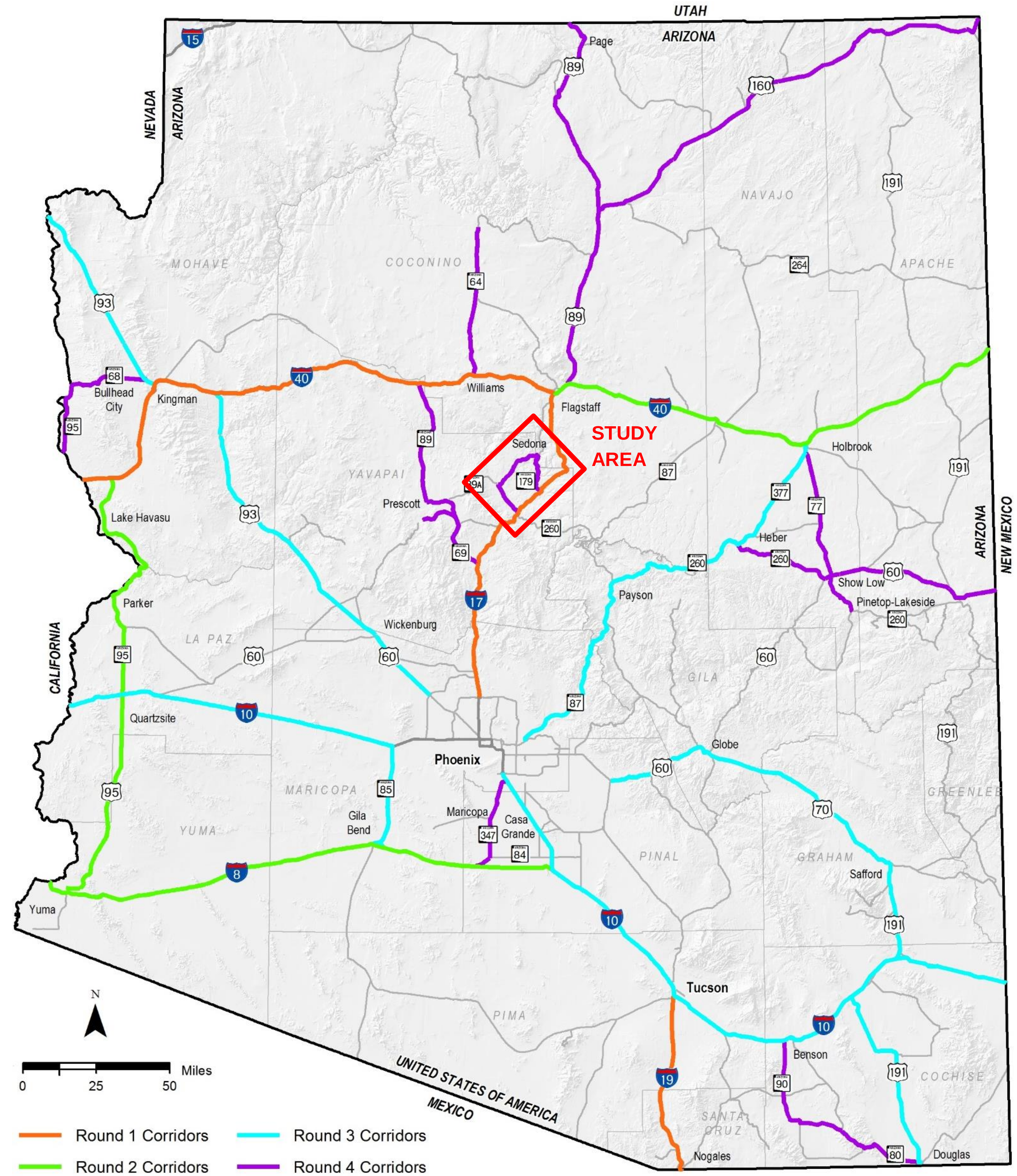
The fourth round (Round 4) of studies began in Spring 2017, and includes:

- SR 69/SR 89: I-17 to I-40
- US 89: I-40 to Utah State Line
- SR 64: I-40 to Grand Canyon National Park
- SR 179/SR 89A/SR 260: I-17 (Camp Verde) to I-17 (Montezuma Well Road)
- SR 347/SR 84: I-10 to I-8
- SR 260: SR 277 to SR 73; US 60: SR 260 to New Mexico State Line
- SR 77: US 60 to SR 377
- SR 68/SR 95 North: US 93 to California State Line
- US 160: US 89 to New Mexico State Line
- SR 90/SR 80: I-10 to US 191

The studies under this program assess the overall health, or performance, of the state's strategic highways. The CPS will identify candidate solutions for consideration in the Multimodal Planning Division's (MPD) P2P project prioritization process, providing information to guide corridor-specific project selection and programming decisions.

The SR 179/SR 89A/SR 260 corridor, depicted in **Figure 1** along with the previous three rounds corridors**,** is one of the strategic statewide corridors identified and the subject of this Round 4 CPS.

Figure 1: Corridor Study Area



1.1 Corridor Overview and Location

The SR 179/SR 89A/SR 260 corridor between I-17 at Exit 298 and I-17 at Exit 287 provides movement for regional, tourism, and recreation needs within Arizona. It provides access to the Verde Valley area. The corridor connects Sedona, Oak Creek, Cottonwood, Camp Verde, Cornville and the Yavapai-Apache Nation. This corridor also serves several recreational areas and National Forests. The SR 179/SR 89A/SR 260 corridor is approximately 46 miles in length.

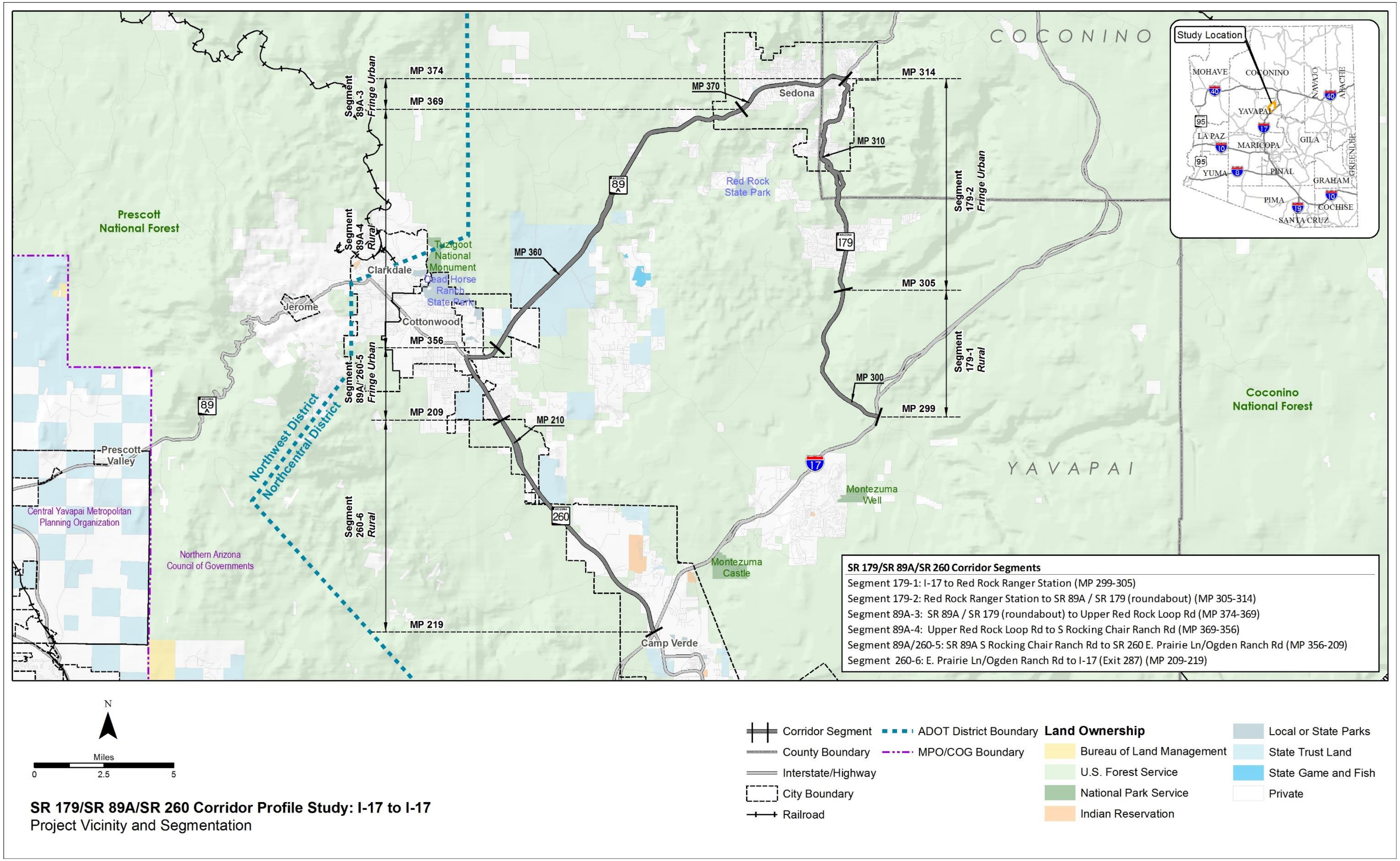
1.2 Corridor Segments

The SR 179/SR 89A/SR 260 corridor is divided into 6 planning segments to allow for an appropriate level of detailed needs analysis, performance evaluation, and comparison between different segments of the corridor. The corridor is segmented at logical breaks where the context changes due to differences in characteristics such as terrain, daily traffic volumes, or roadway typical sections. Corridor segments are described in **Table 1** and shown in **Figure 2**.

Table 1: SR 179/SR 89A/SR 260 Corridor Segments

Segment #	Route	Begin	End	Approx. Begin Milepost	Approx. End Milepost	Approx. Length (miles)	Typical Through Lanes (NB/EB, SB/WB)	2015/2035 Average Annual Daily Traffic Volume (vpd)	Character Description
179-1	SR 179	Interstate 17 (Exit 298)	Red Rock Ranger Station	299	305	6	1,1	7,000/10,000	This rural segment has uninterrupted flow, and a two-lane undivided section, which transitions to a two-lane divided section near the Ranger Station.
179-2	SR 179	Red Rock Ranger Station	SR 89A / SR 179 (roundabout)	305	314	9	1,1	11,000/18,000	This fringe urban segment, which is in the Village of Oak Creek and Sedona, has interrupted flow characteristics, access points, consistent traffic volumes, and a two-lane divided section. This section encompasses a number of roundabouts. There are two passing lane sections between Oak Creek and Sedona, one in each direction. This segment has a number of curves, and climbing sections.
89A-3	SR 89A	SR 89A / SR 179 (roundabout)	Upper Red Rock Loop Road	374	369	5	2,2	22,000/38,000	This fringe urban segment has interrupted flow, and a five-lane undivided section, which is within the City of Sedona.
89A-4	SR 89A	Upper Red Rock Loop Road	S Rocking Chair Ranch Road	369	356	13	2,2	14,000/18,000	This rural segment has interrupted flow and is comprised of a four-lane divided section. There is a traffic signal at the SR 89A/Cornville Road/E. Mingus Avenue intersection.
89A/260-5	SR 89A / SR 260	SR 89A S Rocking Chair Ranch Road	SR 260 E Prairie Lane/Ogden Ranch Road	356 (on SR 89A)	209 (on SR 260)	4	2,2	23,000/33,000	This fringe urban segment has interrupted flow, is comprised of a five-lane undivided section, with access throughout. This segment is in the City of Cottonwood. There is a traffic signal at the SR89A/SR 260 intersection, at the SR 260 intersections with Fir Street, Rodeo Drive, E Del Rio Drive, and Western Drive.
260-6	SR 260	E Prairie Lane/Ogden Ranch Road	I-17 (Exit 287)	209	219	10	2,2 1,1	17,000/23,000	This rural segment has interrupted flow and is comprised of a four-lane divided section and a two-lane undivided section. There are some passing sections in both directions. There is a traffic signal at the SR 260 / Forest Route 372 intersection. There is a four-lane divided section near the I-17 Interchange (Exit 287).

Figure 2: Corridor Location and Segments



2.0 CORRIDOR PERFORMANCE

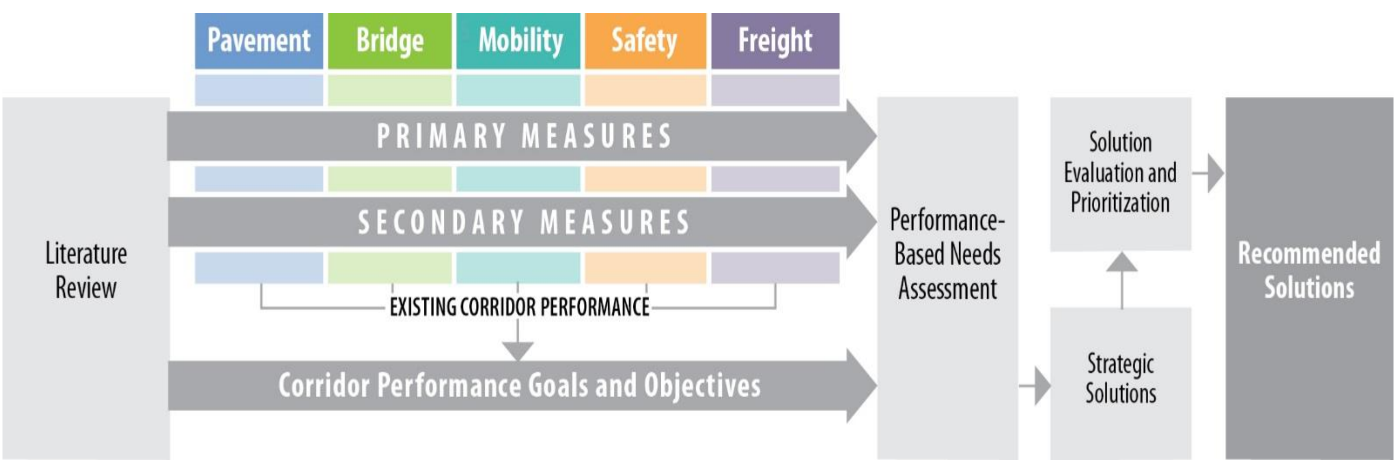
A series of performance measures is used to assess the corridor. The results of the performance evaluation are used to define corridor needs relative to the long-term goals and objectives for the corridor.

2.1 Corridor Performance Framework

This study uses a performance-based process to define baseline corridor performance, diagnose corridor needs, develop corridor solutions, and prioritize strategic corridor investments. In support of this objective, a framework for the performance-based process was developed through a collaborative process involving ADOT and the CPS consultant teams.

Figure 3 illustrates the performance framework, which includes a two-tiered system of performance measures (primary and secondary) to evaluate baseline performance.

Figure 3: Corridor Profile Performance Framework



The following five performance areas guide the performance-based corridor analyses:

- Pavement
- Bridge
- Mobility
- Safety
- Freight

The performance measures include five primary measures: Pavement Index, Bridge Index, Mobility Index, Safety Index, and Freight Index. Additionally, a set of secondary performance measures provides for a more detailed analysis of corridor performance. **Table 2** provides the complete list of primary and secondary performance measures for each of the five performance areas.

Table 2: Corridor Performance Measures

Performance Area	Primary Measure	Secondary Measures
Pavement	**Pavement Index** Based on a combination of International Roughness Index and cracking	• Directional Pavement Serviceability • Pavement Failure • Pavement Hot Spots
Bridge	**Bridge Index** Based on lowest of deck, substructure, superstructure and structural evaluation rating	• Bridge Sufficiency • Functionally Obsolete Bridges • Bridge Rating • Bridge Hot Spots
Mobility	**Mobility Index** Based on combination of existing and future daily volume-to-capacity ratios	• Future Congestion • Peak Congestion • Travel Time Reliability • Multimodal Opportunities
Safety	**Safety Index** Based on frequency of fatal and incapacitating injury crashes	• Directional Safety Index • Strategic Highway Safety Plan Emphasis Areas • Crash Unit Types • Safety Hot Spots
Freight	**Freight Index** Based on bi-directional truck planning time index	• Recurring Delay • Non-Recurring Delay • Closure Duration • Bridge Vertical Clearance • Bridge Vertical Clearance Hot Spots

Each of the primary and secondary performance measures is comprised of one or more quantifiable indicators. A three-level scale was developed to standardize the performance scale across the five performance areas, with numerical thresholds specific to each performance measure:

Good/Above Average Performance – Rating is above the identified desirable/average range

Fair/Average Performance – Rating is within the identified desirable/average range

Poor/Below Average Performance – Rating is below the identified desirable/average range

2.2 Corridor Performance Summary

The following general observations were made related to the performance of the SR 179/SR 89A/SR 260 corridor:

- Overall Performance: The Pavement and Bridge performance areas show "good" or "fair" performance; the Freight performance area shows generally "fair" performance; the Mobility performance area shows a mix of "good", "fair", and "poor" performance; the Safety performance area shows generally "below average" and "average" performance
- Pavement Performance: The weighted average of the Pavement Index shows "good" overall performance for the SR 179/SR 89A/SR 260 corridor; Segment 179-2 shows "fair" or "poor" performance for all Pavement performance area measures; the weighted average for the % Area Failure measure shows "fair" performance for the corridor
- Bridge Performance: The weighted average of the Bridge Index shows "good" overall performance for the SR 179/SR 89A/SR 260 corridor; the weighted average for the Lowest Bridge Rating measure shows "fair" performance for the corridor; Segment 89A-3 contains no bridges
- Mobility Performance: The weighted average of the Mobility Index shows "fair" overall performance for the SR 179/SR 89A/SR 260 corridor; the weighted average Future Daily V/C shows "poor" traffic operations performance; Segment 260-6 shows "poor" or "fair" performance for the Mobility Index, Future Daily V/C, and Existing Peak Hour V/C measures; the weighted average % Bicycle Accommodation measure shows "fair" performance for the corridor
- Safety Performance: The weighted average of the Safety Index and the Directional Safety Index measures show "below average" performance for the SR 179/SR 89A/SR 260 corridor; the weighted average for crashes related to the SHSP Top 5 Emphasis Areas measure shows "above average" performance; there was "insufficient data" for crashes involving trucks, motorcycles, and non-motorized travelers, meaning there was not enough data available to generate reliable performance ratings so no values were calculated
- Freight Performance: The weighted average of the Freight Index shows "fair" overall performance for the SR 179/SR 89A/SR 260 corridor; the Directional TTTI measures shows "good" or "fair" performance along the corridor; Segments 89A-3 and 89A/260-5 show "poor" performance for the Directional TPTI measure in at least one direction; the weighted average for the Directional TPTI measure along the corridor shows "fair" performance; Segment 89A-4 in the NB/WB direction shows "poor" performance in the Closure Duration performance measure
- Lowest Performing Segments: Segments 89A-3, 89A-4, and 260-6 show "poor/below average" performance for many performance measures
- Highest Performing Segments: Segments 179-1 and 89A-4 show "good/above average" performance for many performance measures

Figure 4 shows the percentage of the SR 179/SR 89A/SR 260 corridor that rates either "good/above average" performance, "fair/average" performance, or "poor/below average" performance for each primary measure. On the SR 179/SR 89A/SR 260 corridor, Safety is the lowest performing area with 68% of the corridor having "below average" performance as it relates to the primary measure. The Pavement and Bridge performance areas are the highest performing areas on the SR 179/SR 89A/SR 260 corridor with 68% and 64% of the corridor, respectively, having "good" performance as it relates to the primary measures. The Mobility and Freight performance areas show a more even mix of "good", "fair", and "poor" performance.

Table 3 shows a summary of corridor performance for all primary measures and secondary measure indicators for the SR 179/SR 89A/SR 260 corridor. A weighted corridor average rating (based on the length of the segment) was calculated for each primary and secondary measure.

Figure 4: Performance Summary by Primary Measure

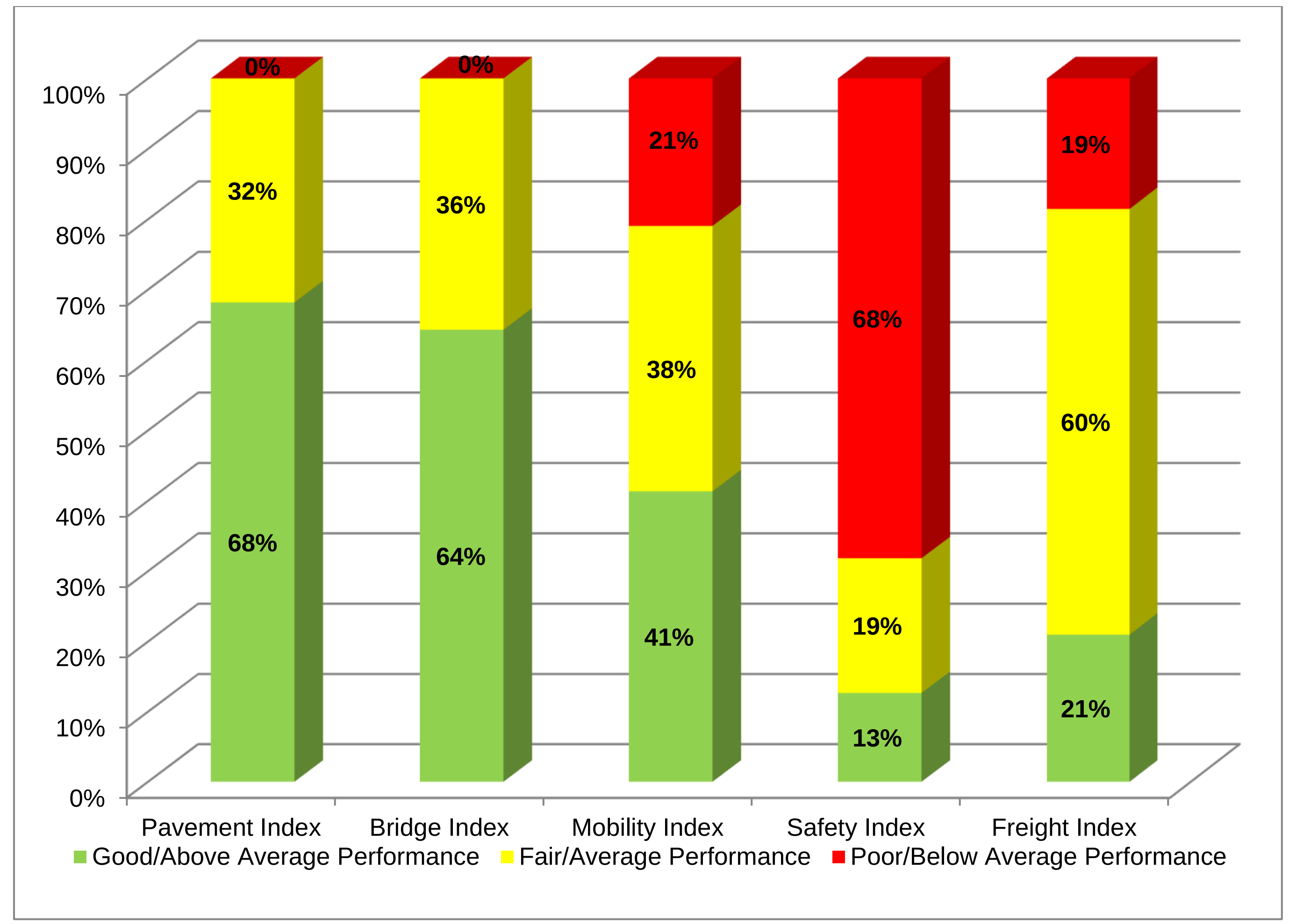


Table 3: Corridor Performance Summary by Segment and Performance Measure

Segment #	Segment Length (miles)	Pavement Performance Area				Bridge Performance Area				Mobility Performance Area											
		Pavement Index	Directional PSR		% Area Failure	Bridge Index	Sufficiency Rating	% of Deck Area on Functionally Obsolete Bridges	Lowest Bridge Rating	Mobility Index	Future Daily V/C	Existing Peak Hour V/C		Closure Extent (instances/ milepost/year/mile)		Directional TTI (all vehicles)		Directional PTI (all vehicles)		% Bicycle Accommodation	% Non-Single Occupancy Vehicle (SOV) Trips
			SB/EB (& NB 179)	NB/WB (& SB 179)								NB/WB (& SB 179)	SB/EB (& NB 179)	NB/WB (& SB 179)	SB/EB (& NB 179)	NB/WB (& SB 179)	SB/EB (& NB 179)	NB/WB (& SB 179)	SB/EB (& NB 179)		
179-1[2*c]	6	3.27	3.31	3.24	0.0%	5.00	59.90	100.0%	5	0.35	0.41	0.27	0.26	0.00	0.10	1.17	1.21	2.81	3.55	4%	17.1%
179-2[1*a]	9	3.31	3.33	3.28	27.8%	8.00	90.27	0.0%	8	0.83	1.01	0.57	0.56	0.09	0.02	1.27	1.33	3.39	4.37	100%	17.0%
89A-3[1*b]	5	3.71	3.51	3.46	0.0%	No Bridges				0.86	1.08	0.54	0.54	0.00	0.16	1.29	1.24	6.97	5.55	71%	17.9%
89A-4[2*a]	13	3.87	3.75	3.75	0.0%	5.31	98.81	0.0%	5	0.48	0.54	0.34	0.33	0.54	0.03	1.15	1.08	3.24	1.88	97%	18.0%
89A/260-5[1*b]	4	3.97	3.61	3.61	0.0%	7.00	84.00	0.0%	7	0.77	0.90	0.57	0.53	0.05	0.10	1.30	1.27	5.29	3.02	29%	20.1%
260-6[2*c]	10	3.89	3.65	3.76	6.7%	6.95	91.24	0.0%	5	1.22	1.40	0.76	0.76	0.12	0.12	1.01	1.07	1.33	1.97	90%	16.1%
Weighted Corridor Average		3.68	3.56	3.55	6.7%	6.57	90.44	7.1%	5.79	0.75	0.88	0.50	0.49	0.20	0.08	1.17	1.17	3.36	3.05	73%	17.5%
SCALES																					
Performance Level		**Non-Interstate**				**All**				**Urban and Fringe Urban**				**All**		**Uninterrupted**				**All**	
Good/Above Average		> 3.50			< 5%	> 6.5	> 80	< 12%	> 6	< 0.71				< 0.22		< 1.15		< 1.3		> 90%	> 17%
Fair/Average		2.90 - 3.50			5% - 20%	5.0 - 6.5	50 - 80	12% - 40%	5 - 6	0.71 - 0.89				0.22 - 0.62		1.15 - 1.33		1.3 - 1.5		60% - 90%	11% - 17%
Poor/Below Average		< 2.90			> 20%	< 5.0	< 50	> 40%	< 5	> 0.89				> .62		> 1.33		> 1.5		< 60%	< 11%
Performance Level										**Rural**						**Interrupted**					
Good/Above Average										< 0.56						< 1.3		< 3.0			
Fair/Average										0.56 - 0.76						1.3 – 2.0		3.0 – 6.0			
Poor/Below Average										> 0.76						> 2.0		> 6.0			

^Uninterrupted Flow Facility
*Interrupted Flow Facility
[a]2 or 3 or 4 Lane Divided Highway
[b]4 or 5 Lane Undivided Highway
[c]2 or 3 Lane Undivided Highway
[1]Urban Operating Environment
[2]Rural Operating Environment

Table 3: Corridor Performance Summary by Segment and Performance Measure (continued)

Segment #	Segment Length (miles)	Safety Performance Area							Freight Performance Area							
		Safety Index	Directional Safety Index		% of Fatal + Incapacitating Injury Crashes Involving SHSP Top 5 Emphasis Areas Behaviors	% of Fatal + Incapacitating Injury Crashes Involving Trucks	% of Fatal + Incapacitating Injury Crashes Involving Motorcycles	% of Fatal + Incapacitating Injury Crashes Involving Non-Motorized Travelers	Freight Index	Directional TTTI		Directional TPTI		Closure Duration (minutes/milepost/year/mile)		Bridge Vertical Clearance (feet)
			NB/WB (& SB 179)	SB/EB (& NB 179)						NB/WB (& SB 179)	SB/EB (& NB 179)	NB/WB (& SB 179)	SB/EB (& NB 179)	NB/WB (& SB 179)	SB/EB (& NB 179)	
179-1[2*c]	5	0.13	0.26	0.00	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	0.24	1.25	1.27	3.16	5.33	0.00	12.13	No UP
179-2[1*a]	9	0.79	0.79	0.79	50%	Insufficient Data	Insufficient Data	Insufficient Data	0.20	1.48	1.42	4.06	5.97	21.76	4.18	No UP
89A-3[1*b]	22	1.37	0.12	2.62	57%	Insufficient Data	Insufficient Data	Insufficient Data	0.15	1.43	1.33	6.43	7.21	0.00	48.84	No UP
89A-4[2*a]	22	2.05	0.98	3.13	56%	Insufficient Data	Insufficient Data	Insufficient Data	0.27	1.28	1.16	4.38	3.14	145.51	7.40	No UP
89A/260-5[1*b]	5	2.22	4.24	0.19	27%	Insufficient Data	Insufficient Data	Insufficient Data	0.14	1.50	1.40	9.47	5.17	9.90	13.40	No UP
260-6[2*c]	10	2.19	2.19	2.19	33%	Insufficient Data	Insufficient Data	Insufficient Data	0.42	1.05	1.14	1.58	3.16	19.82	27.98	No UP
Weighted Corridor Average		1.54	1.30	1.79	46%	Insufficient Data	Insufficient Data	Insufficient Data	0.26	1.30	1.26	4.22	4.55	50.88	16.35	No UP

SCALES

Performance Level	2 or 3 or 4 Lane Divided Highway					Uninterrupted			All	
Good/Above Average	< 0.77	< 44%	< 4%	< 16%	< 2%	> 0.77	< 1.15	< 1.3	< 44.18	> 16.5
Fair/Average	0.77 - 1.23	44% - 54%	4% - 7%	16% - 26%	2% - 4%	0.67 - 0.77	1.15 - 1.33	1.3 - 1.5	44.18-124.86	16.0 - 16.5
Poor/Below Average	> 1.23	> 54%	> 7%	> 26%	> 4%	< 0.67	> 1.33	> 1.5	> 124.86	< 16.0
Performance Level	**2 or 3 Lane Undivided Highway**					**Interrupted**				
Good/Above Average	< 0.94	< 51%	< 6%	< 19%	< 5%	> 0.33	< 1.3	< 3.0		
Fair/Average	0.94 - 1.06	51% - 58%	6% - 10%	19% - 27%	5% - 8%	0.17 - 0.33	1.3 - 2.0	3.0 - 6.0		
Poor/Below Average	> 1.06	> 58%	> 10%	> 27%	> 8%	< 0.17	> 2.0	> 6.0		
Performance Level	**4 or 5 Undivided Highway**									
Good/Above Average	< 0.80	< 42%	< 6%	< 6%	< 5%					
Fair/Average	0.80 - 1.20	42% - 51%	6% - 10%	6% - 9%	5% - 8%					
Poor/Below Average	> 1.20	> 51%	> 10%	> 9%	> 8%					

^Uninterrupted Flow Facility
*Interrupted Flow Facility
[a]2 or 3 or 4 Lane Divided Highway
[b]4 or 5 Lane Undivided Highway
[c]2 or 3 Lane Undivided Highway
[1]Urban Operating Environment
[2]Rural Operating Environment

Notes: *"Insufficient Data" indicates there was not enough data available to generate reliable performance ratings*
"No UP" indicates no underpasses are present in the segment

3.0 NEEDS ASSESSMENT

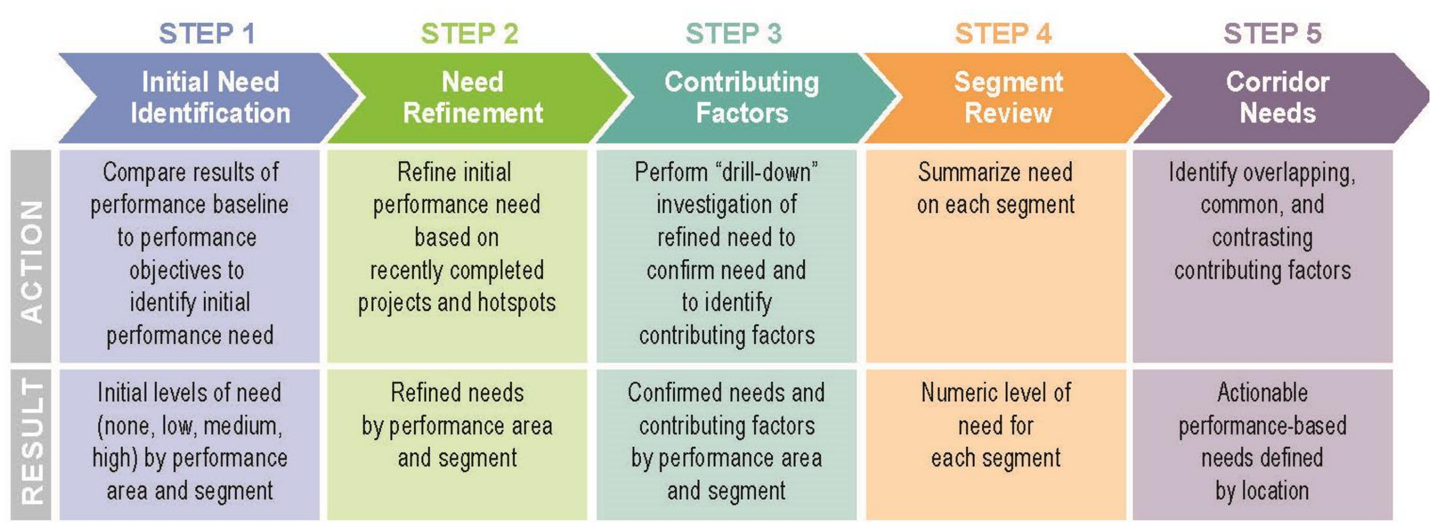
3.1 Needs Assessment Process

The following guiding principles were used as an initial step in developing a framework for the performance-based needs assessment process:

- Corridor needs are defined as the difference between the corridor performance and the performance objectives
- The needs assessment process should be systematic, progressive, and repeatable, but also allow for engineering judgment where needed
- The process should consider all primary and secondary performance measures developed for the study
- The process should develop multiple need levels including programmatic needs for the entire length of the corridor, performance area-specific needs, segment-specific needs, and location-specific needs (defined by MP limits)
- The process should produce actionable needs that can be addressed through strategic investments in corridor preservation, modernization, and expansion

The performance-based needs assessment process is illustrated in **Figure 5**.

Figure 5: Needs Assessment Process



Step 1: Initial Needs Identification

The needs assessment compares baseline corridor performance with performance objectives to provide a starting point for the identification of performance needs. This mathematical comparison results in an initial need rating of None, Low, Medium, or High for each primary and secondary performance measure. An illustrative example of this process is shown below in **Figure 6**.

Figure 6: Initial Need Ratings in Relation to Baseline Performance (Bridge Example)

Performance Thresholds	Performance Level	Initial Level of Need	Description
	Good	None*	All levels of Good and top 1/3 of Fair (>6.0)
	Good		
6.5	Good		
	Fair		
	Fair	Low	Middle 1/3 of Fair (5.5-6.0)
5.0	Fair	Medium	Lower 1/3 of Fair and top 1/3 of Poor (4.5-5.5)
	Poor		
	Poor	High	Lower 2/3 of Poor (<4.5)
	Poor		

**A segment need rating of 'None' does not indicate a lack of needed improvements; rather, it indicates that the segment performance score exceeds the established performance thresholds and strategic solutions for that segment will not be developed as part of this study.*

The initial level of need for each segment is refined to account for hot spots and recently completed or under construction projects, resulting in a final level of need for each segment. The final levels of need for each primary and secondary performance measure are combined to produce a weighted final need rating for each segment. A detailed review of available data helps identify contributing factors to the need and if there is a high level of historical investment.

3.2 Summary of Corridor Needs

The needs in each performance area are shown in **Table 4** and **Figure 7** and summarized below:

Pavement Needs

- Two segments (179-2 and 89A/260-5) contain Pavement hot spots
- Segments 179-1, 179-2, and 260-6 have a final segment need of Low; all other segments on the corridor have final segment need of None
- Segment 89A/260-5 was identified as having potential pavement repetitive historical investment issues

Bridge Needs

- There are no bridge hot spots along the corridor but there are three bridges that have potential repetitive historical investment issues
- Segment 179-1 has a final segment need of High; the segment contains one bridge which is functionally obsolete and has one evaluation rating of 5
- Segment 89A-4 has a final segment need of Medium; Segment 260-6 has a final segment need of Low; all other segments have a final segment need of None

Mobility Needs

- Segments 179-2, 89A-3, and 260-6 have a final segment need of High; all other segments on the corridor have final segment need of Low
- Mobility needs are related to high existing and projected traffic volumes, high PTI, and lack of bicycle accommodation

Safety Needs

- All segments have a final segment need of High except Segments 179-1 and 179-2, which have final segment needs of None and Low, respectively
- Safety hot spots exist in Segments 89A-3, 89A-4, 89A/260-5, and 260-6
- Crashes involving SHSP Top 5 Emphasis Area Behaviors are above the statewide average for Segments 179-2 and 89A-3

Freight Needs

- No freight hot spots exist along the corridor
- Segment 89A/260-5 and Segment 89A-3 has a final segment need of High while Segment 179-2 has a final segment need of Medium; all other segments on the corridor have a final segment need of Low
- Freight needs are primarily related to the Freight Index and high PTI

Overlapping Needs

This section identifies overlapping performance needs on the SR 179/SR 89A/SR 260 corridor, which provides guidance to develop strategic solutions that address more than one performance area with elevated levels of need (i.e., Medium or High). Completing projects that address multiple needs presents the opportunity to more effectively improve overall performance. A summary of the overlapping needs that relate to locations with elevated levels of need is provided below:

- Segment 89A-3, which has the highest average need score of all the segments of the corridor, has elevated needs in the Mobility, Safety, and Freight performance areas
- Segment 179-2 contains elevated needs in the Mobility and Freight performance areas
- Segment 89A-4 contains elevated needs in the Bridge and Safety performance areas
- Segment 260-5 contains elevated needs in the Safety and Freight performance areas
- Segment 260-6 contains elevated needs in the Mobility and Safety performance areas

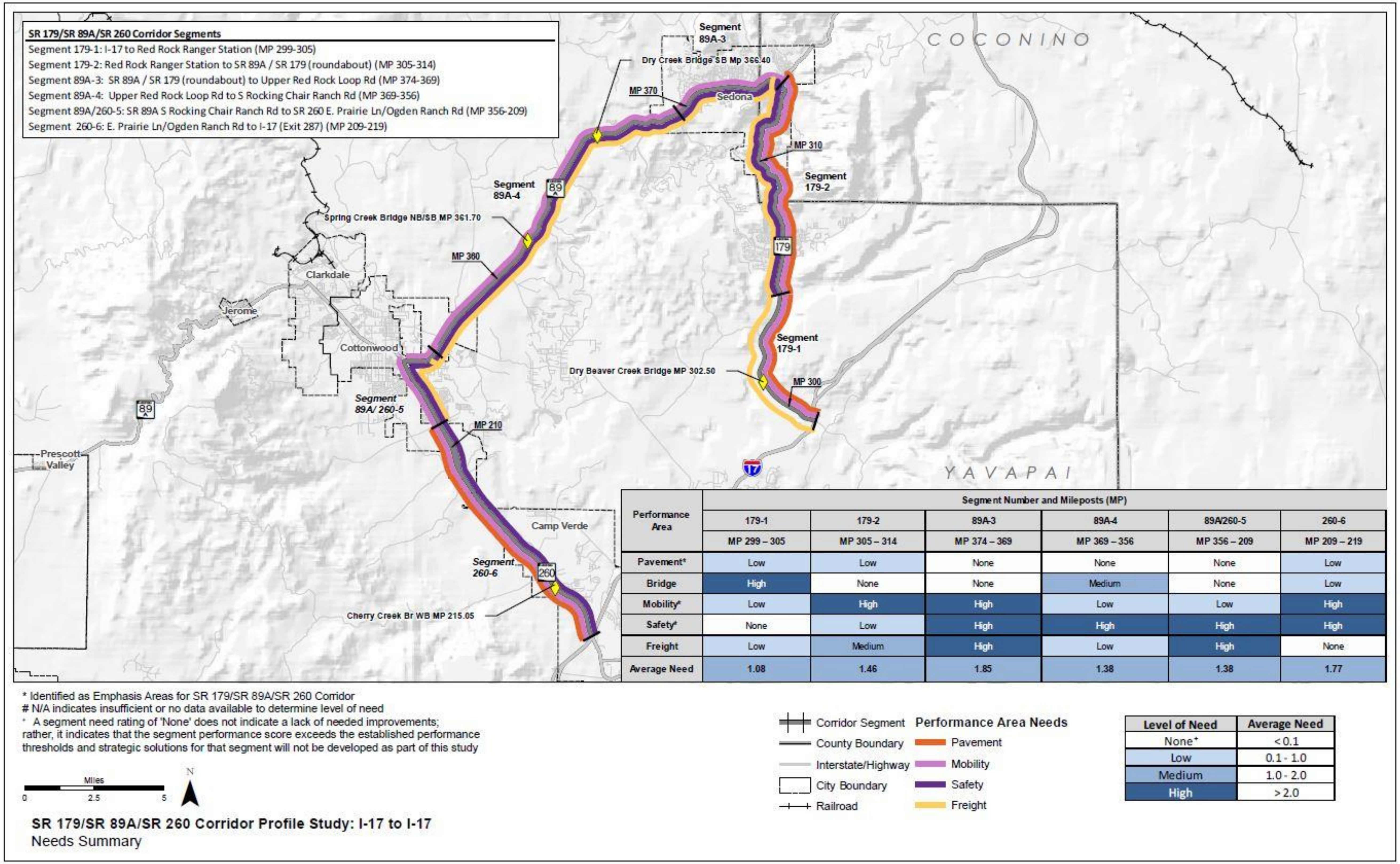
Table 4: Summary of Needs by Segment

Performance Area	Segment Number and Mileposts (MP)					
	179-1	179-2	89A-3	89A-4	89A/260-5	260-6
	MP 299 – 305	MP 305 – 314	MP 374 – 369	MP 369 – 356	MP 356 – 209	MP 209 – 219
Pavement*	Low	Low	None	None	None	Low
Bridge	High	None	None	Medium	None	Low
Mobility*	Low	High	High	Low	Low	High
Safety*	None	Low	High	High	High	High
Freight	Low	Medium	High	Low	High	None
Average Need	**1.08**	**1.46**	**1.85**	**1.38**	**1.38**	**1.77**

* Identified as Emphasis Areas for SR 179/SR 89A/SR 260Corridor
# N/A indicates insufficient or no data available to determine level of need
+ A segment need rating of 'None' does not indicate a lack of needed improvements; rather, it indicates that the segment performance score exceeds the established performance thresholds and strategic solutions for that segment will not be developed as part of this study

Level of Need	Average Need Range
None+	< 0.1
Low	0.1 - 1.0
Medium	1.0 - 2.0
High	> 2.0

Figure 7: Corridor Needs Summary



Performance Area	Segment Number and Mileposts (MP)					
	179-1	179-2	89A-3	89A-4	89A/260-5	260-6
	MP 299 – 305	MP 305 – 314	MP 374 – 369	MP 369 – 356	MP 356 – 209	MP 209 – 219
Pavement*	Low	Low	None	None	None	Low
Bridge	High	None	None	Medium	None	Low
Mobility*	Low	High	High	Low	Low	High
Safety*	None	Low	High	High	High	High
Freight	Low	Medium	High	Low	High	None
Average Need	1.08	1.46	1.85	1.38	1.38	1.77

Level of Need	Average Need
None+	< 0.1
Low	0.1 - 1.0
Medium	1.0 - 2.0
High	> 2.0

4.0 STRATEGIC SOLUTIONS

The principal objective of the CPS is to identify strategic solutions (investments) that are performance-based to ensure that available funding resources are used to maximize the performance of the State's key transportation corridors. One of the first steps in the development of strategic solutions is to identify areas of elevated levels of need (i.e., Medium or High). Addressing areas of Medium or High need will have the greatest effect on corridor performance and are the focus of the strategic solutions. Segments with Medium or High needs and specific locations of hot spots are considered strategic investment areas for which strategic solutions should be developed. Segments with lower levels of need or without identified hot spots are not considered candidates for strategic investment and are expected to be addressed through other ADOT programming processes. The SR 179/SR 89A/SR 260 strategic investment areas (resulting from the elevated needs) are shown in **Figure 8**.

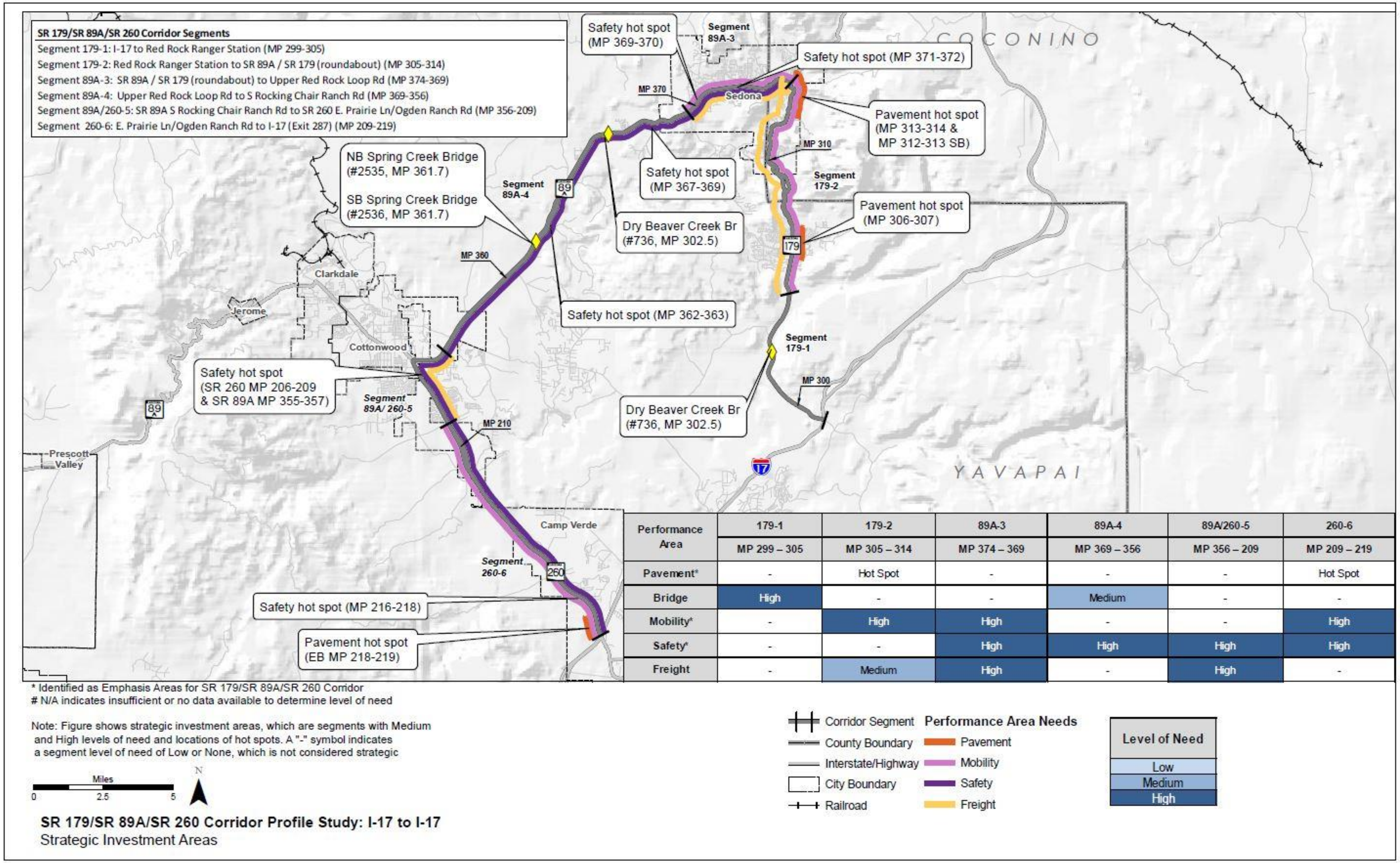
4.1 Screening Process

This section examines qualifying strategic needs and determines if the needs in those locations require action. In some cases, needs that are identified do not advance to solutions development and are screened out from further consideration because they have been or will be addressed through other measures, including:

- A project is programmed to address this need
- The need is a result of a Pavement or Bridge hot spot that does not show historical investment or rating issues; these hot spots will likely be addressed through other ADOT programming means
- A bridge is not a hot spot but is located within a segment with a Medium or High level of need; this bridge will likely be addressed through current ADOT bridge maintenance and preservation programming processes
- The need is determined to be non-actionable (i.e., cannot be addressed through an ADOT project)
- The conditions/characteristics of the location have changed since the performance data was collected that was used to identify the need

Table 5 notes if each potential strategic need advanced to solution development, and if not, the reason for screening the potential strategic need out of the process. Locations advancing to solutions development are marked with Yes (Y); locations not advancing are marked with No (N) and highlighted. This screening table provides specific information about the needs in each segment that will be considered for strategic investment. The table identifies the level of need – either Medium or High segment needs, or segments without Medium or High level of need that have a hot spot. Each area of need is assigned a location number in the screening table to help document and track locations considered for strategic investment.

Figure 8: Strategic Investment Areas



Performance Area	179-1	179-2	89A-3	89A-4	89A/260-5	260-6
	MP 299 – 305	MP 305 – 314	MP 374 – 369	MP 369 – 356	MP 356 – 209	MP 209 – 219
Pavement*	-	Hot Spot	-	-	-	Hot Spot
Bridge	High	-	-	Medium	-	-
Mobility*	-	High	High	-	-	High
Safety*	-	-	High	High	High	High
Freight	-	Medium	High	-	High	-

* Identified as Emphasis Areas for SR 179/SR 89A/SR 260 Corridor
# N/A indicates insufficient or no data available to determine level of need

Note: Figure shows strategic investment areas, which are segments with Medium and High levels of need and locations of hot spots. A "-" symbol indicates a segment level of need of Low or None, which is not considered strategic

Table 5: Strategic Investment Area Screening

Segment # and MP	Level of Strategic Need: Pavement	Level of Strategic Need: Bridge	Level of Strategic Need: Mobility	Level of Strategic Need: Safety	Level of Strategic Need: Freight	Location #	Type	Need Description	Advance (Y/N)	Screening Description
179-1 (MP 299-305)		High				L1	Bridge	Dry Beaver Creek Br (#736, MP 302.5) has 2015 deck rating of 5; not identified in historical review; is not considered a hot spot	N	Bridge does not have a rating of 4 or multiple ratings of 5 so it is not a hot spot and therefore is not considered a strategic investment; will likely be addressed by current ADOT processes
179-2 (MP 305-314)	Hot Spot		High		Medium	L2	Pavement	Hot spots MP 306-307, MP 313-314, Hot spots MP 312-313 SB	N	No high historical investment so not considered a strategic investment; will likely be addressed by current ADOT processes
						L3	Mobility	MP 305-314 has a High level of need based on Future Daily V/C performance; Mobility Index and Directional PTI ratings are fair	Y	No programmed project to address Mobility need
						L4	Freight	MP 305-314 has a Medium level of need based on fair overall Freight Index, Directional TTTI, and Directional TPTI measures	Y	No programmed project to address Freight need
89A-3 (MP 374-369			High	High	High	L5	Mobility	MP 374-369 has a High level of need based on Future Daily V/C and NB/WB Directional PTI performance; Mobility Index, SB/EB Directional PTI, and Bicycle Accommodation ratings are fair	Y	No programmed project to address Mobility need
						L6	Safety	MP 374-369 has an overall Safety Index and SB/EB Directional Safety Index above statewide averages Hot spots MP 369-370 and MP 371-372 3 fatal crashes, 4 incapacitating crashes, and 2 crashes involving motorcycles; crash data analysis indicates percentage of crashes above statewide average related to SHSP Top 5 Emphasis Areas Behaviors; 29% involve head on, 29% involve failure to yield right-of-way	Y	No programmed project to address Safety need
						L7	Freight	MP 374-369 has a High level of need based on poor overall Freight Index and Directional TPTI ratings; Directional TTTI ratings are fair	Y	No programmed project to address Freight need

Table 5: Strategic Investment Area Screening (continued)

Segment # and MP	Level of Strategic Need: Pavement	Bridge	Mobility	Safety	Freight	Location #	Type	Need Description	Advance (Y/N)	Screening Description
89A-4 (MP 369-356)		Medium		High		L8	Bridge	Spring Creek Bridge NB (#2535, MP 361.7) has 2015 deck rating of 5; not identified in historical review; is not considered a hot spot	N	Bridge does not have a rating of 4 or multiple ratings of 5 so it is not a hot spot and therefore is not considered a strategic investment; will likely be addressed by current ADOT processes
89A-4 (MP 369-356)		Medium		High		L9	Bridge	Spring Creek Bridge SB (#2536, MP 361.7) has 2015 deck rating of 5; not identified in historical review; is not considered a hot spot	N	Bridge does not have a rating of 4 or multiple ratings of 5 so it is not a hot spot and therefore is not considered a strategic investment; will likely be addressed by current ADOT processes
89A-4 (MP 369-356)		Medium		High		L10	Bridge	Dry Creek Bridge SB (#2534, MP 366.40) has 2015 current deck rating of 5; identified in historical review due to three decreases in bridge ratings; is not considered a hot spot	N	Bridge does not have a rating of 4 or multiple ratings of 5 so it is not a hot spot and therefore is not considered a strategic investment; will likely be addressed by current ADOT processes
89A-4 (MP 369-356)		Medium		High		L11	Safety	MP 369-356 has an overall Safety Index and SB/EB Directional Safety Index above statewide averages Hot spots MP 362-363 and MP 367-369 9 fatal crashes, 9 incapacitating crashes, 1 crash involving trucks, 2 crashes involving motorcycles, and 1 crash involving a pedestrian; crash data analysis indicates percentage of crashes above statewide average related to SHSP Top 5 Emphasis Areas Behaviors; 56% involve a first unit event of ran off the road (left), 22% involve a first unit event of ran off the road (right), 28% involve under the influence of drugs or alcohol, 56% involve no safety device usage	Y	No programmed project to address Safety need
89A/260-5 (MP 356-209)				High	High	L12	Safety	MP 356-209 has an overall Safety Index and NB/WB Directional Safety Index above statewide averages Hot spot MP 206-209 (on SR 260) through MP 355-357 (on SR 89A) 4 fatal crashes, 11 incapacitating crashes, 2 crashes involving trucks, and 2 crashes involving a pedestrian; crash data analysis indicates; 38% involve left turns, 23% involve failure to yield right-of-way, 31% involve dark-unlighted conditions	Y	No programmed project to address Safety need
89A/260-5 (MP 356-209)				High	High	L13	Freight	MP 356-209 has a High level of need based on poor overall Freight Index and NB/WB Directional TPTI ratings; Directional TTTI and SB/EB Directional TPTI ratings are fair	Y	No programmed project to address Freight need

Legend: Strategic investment area screened out from further consideration

Table 5: Strategic Investment Area Screening (continued)

Segment # and MP	Level of Strategic Need					Location #	Type	Need Description	Advance (Y/N)	Screening Description
	Pavement	Bridge	Mobility	Safety	Freight					
260-6 (MP 209-219)	Hot Spot		High	High		L14	Pavement	Hot spot EB MP 218-219	N	SR 260 widening project under construction expected to address Pavement need; No high historical investment so not considered a strategic investment
						L15	Mobility	MP 209-219 has a High level of need based on Mobility Index and Future Daily V/C performance; Existing Peak Hour V/C and Bicycle Accommodation ratings are fair	N	SR 260 widening project under construction expected to address Mobility need
						L16	Safety	MP 209-219 has an overall Safety Index and Directional Safety Indices above statewide averages Hot spot MP 216-218 4 fatal crashes, 8 incapacitating crashes, 2 crashes involving trucks, and 1 crash involving motorcycles; crash data analysis indicates; 25% involve collision with a fixed object, 25% involve rear end, 25% involve head on, 17% involve made improper turn, 17% involve failure to keep in proper lane, 17% involve drove in opposing lane, 25% involve dark-unlighted conditions	N	SR 260 widening project under construction expected to address Safety need

Legend: Strategic investment area screened out from further consideration

4.2 Candidate Solutions

For each elevated need within a strategic investment area that is not screened out, a candidate solution is developed to address the identified need. Each candidate solution is assigned to one of the following three P2P investment categories based on the scope of the solution:

- Preservation
- Modernization
- Expansion

Documented performance needs serve as the foundation for developing candidate solutions for corridor preservation, modernization, and expansion. Candidate solutions are not intended to be a substitute or replacement for traditional ADOT project development processes where various ADOT technical groups and districts develop candidate projects for consideration in the performance-based programming in the P2P process. Rather, these candidate solutions are intended to complement ADOT's traditional project development processes through a performance-based process to address needs in one or more of the five performance areas of Pavement, Bridge, Mobility, Safety, and Freight. Candidate solutions developed for the SR 179/SR 89A/SR 260 corridor will be considered along with other candidate projects in the ADOT statewide programming process.

Characteristics of Strategic Solutions

Candidate solutions should include some or all of the following characteristics:

- Do not recreate or replace results from normal programming processes
- May include programs or initiatives, areas for further study, and infrastructure projects
- Address elevated levels of need (High or Medium) and hot spots
- Focus on investments in modernization projects (to optimize current infrastructure)
- Address overlapping needs
- Reduce costly repetitive maintenance
- Extend operational life of system and delay expansion
- Leverage programmed projects that can be expanded to address other strategic elements
- Provide measurable benefit

Candidate Solutions

A set of 4 candidate solutions are proposed to address the identified needs on the SR 179/SR 89A/SR 260 corridor.

Table 6 identifies each strategic location that has been assigned a candidate solution with a number (e.g., CS179.1, CS89A.2, etc.). Each candidate solution is comprised of one or more components to address the identified needs. The assigned candidate solution numbers are linked to the location number and provide tracking capability through the rest of the process. The locations of proposed solutions are shown on the map in **Figure 9**.

Candidate solutions developed to address an elevated need in the Pavement or Bridge performance area will include two options: rehabilitation or full replacement. These solutions are initially evaluated through a Life-Cycle Cost Analysis (LCCA) to provide insights into the cost-effectiveness of these options so a recommended approach can be identified. Candidate solutions developed to address an elevated need in the Mobility, Safety, or Freight performance areas are advanced directly to the Performance Effectiveness Evaluation. In some cases, there may be multiple solutions identified to address the same area of need.

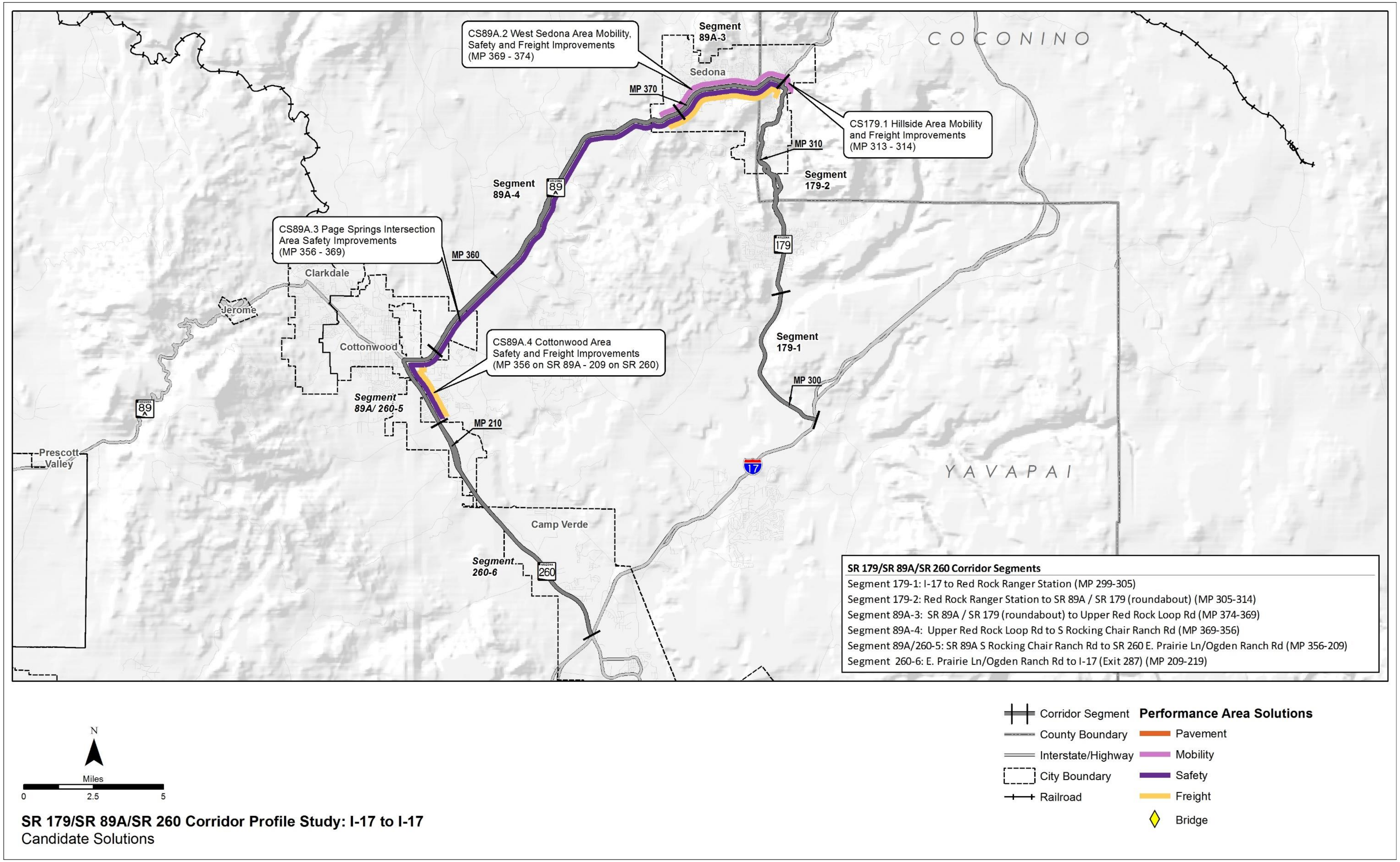
Candidate solutions that are recommended to expand or modify the scope of an already programmed project are noted and are not advanced to solution evaluation and prioritization. These solutions are directly recommended for programming.

Table 6: Candidate Solutions

Candidate Solution #	Segment #	Location #	Beginning Milepost	Ending Milepost	Candidate Solution Name	Option*	Scope	Investment Category (Preservation [P], Modernization [M], Expansion [E])
CS179.1	179-2	L3/L4	313	314	SR 179 Hillside Area Mobility and Freight Improvements	-	-Expand Schnebly Hill Road roundabout to 2 lanes (MP 313.1) -Widen to 4 lanes between Schnebly Hill Road (MP 313.0) roundabout and SR 179/SR 89A roundabout (the "Y") (MP 313.4) -Construct a pedestrian tunnel or bridge at Tlaquepaque, replacing the existing crosswalk -Construct separated right-turn lane towards SB SR 179 and separated right-turn lane towards Uptown at SR 179/SR 89A roundabout (the "Y") (MP 313.4)	E
CS89A.2	89A-3	L5/L6/L7	369	374	West Sedona Area Safety, Mobility, and Freight Improvements	-	-Construct continuous raised median between MP 370.5 and MP 374.0 -Implement signal communication, coordination, and adaptive traffic control from Upper Red Rock Loop Rd (MP 369.6) to Airport Rd (MP 373.1), a total of 8 signals	M
CS89A.3	89A-4	L11	356	369	Page Springs Road Intersection Area Safety Improvements	-	-Intersection reconstruction, MP 362.5 (Page Springs Road) -Rehabilitate shoulders in both directions (striping, delineators, RPMs, safety edge, and rumble strips for both shoulders), MP 356.5-369.6 -Install chevrons, curve warning signs with beacons, and speed reduced ahead signs, MP 368.2-369.0 -Install speed feedback signs approaching curves, SB MP 369 and NB MP 368 -Install chevrons and curve warning signs with beacons either side of curve at MP 366	M
CS89A/ 260.4	89A /260-5	L12/L13	356 on SR 89A	209 on SR 260	Cottonwood Area Safety and Freight Improvements	-	-Install lighting and raised median at Rio Mesa Trail intersection, MP 207.2 -Improve signal visibility at Western Drive intersection, MP 208.8 -Construct continuous raised median, MP 208-209 -Implement signal communication, coordination and adaptive traffic control on SR 260/SR 89A from Cornville Road (MP 357.1 on SR 89A) to Western Drive (MP 208.8 on SR 260), total of 7 signals	M

* '-': Indicates only one solution is being proposed and no options are being considered

Figure 9: Candidate Solutions



5.0 SOLUTION EVALUATION AND PRIORITIZATION

Candidate solutions are evaluated using the following steps: LCCA (where applicable), Performance Effectiveness Evaluation, Solution Risk Analysis, and Candidate Solution Prioritization. The methodology and approach to this evaluation are shown in **Figure 10** and described more fully below.

Life-Cycle Cost Analysis

All Pavement and Bridge candidate solutions have two options: rehabilitation/repair or reconstruction. These options are evaluated through an LCCA to determine the best approach for each location where a Pavement or Bridge solution is recommended. The LCCA can eliminate options from further consideration and identify which options should be carried forward for further evaluation.

When multiple independent candidate solutions are developed for Mobility, Safety, or Freight strategic investment areas, these candidate solution options advance directly to the Performance Effectiveness Evaluation without an LCCA.

Performance Effectiveness Evaluation

After completing the LCCA process, all remaining candidate solutions are evaluated based on their performance effectiveness. This process includes determining a Performance Effectiveness Score (PES) based on how much each solution impacts the existing performance and needs scores for each segment. This evaluation also includes a Performance Area Risk Analysis to help differentiate between similar solutions based on factors that are not directly addressed in the performance system.

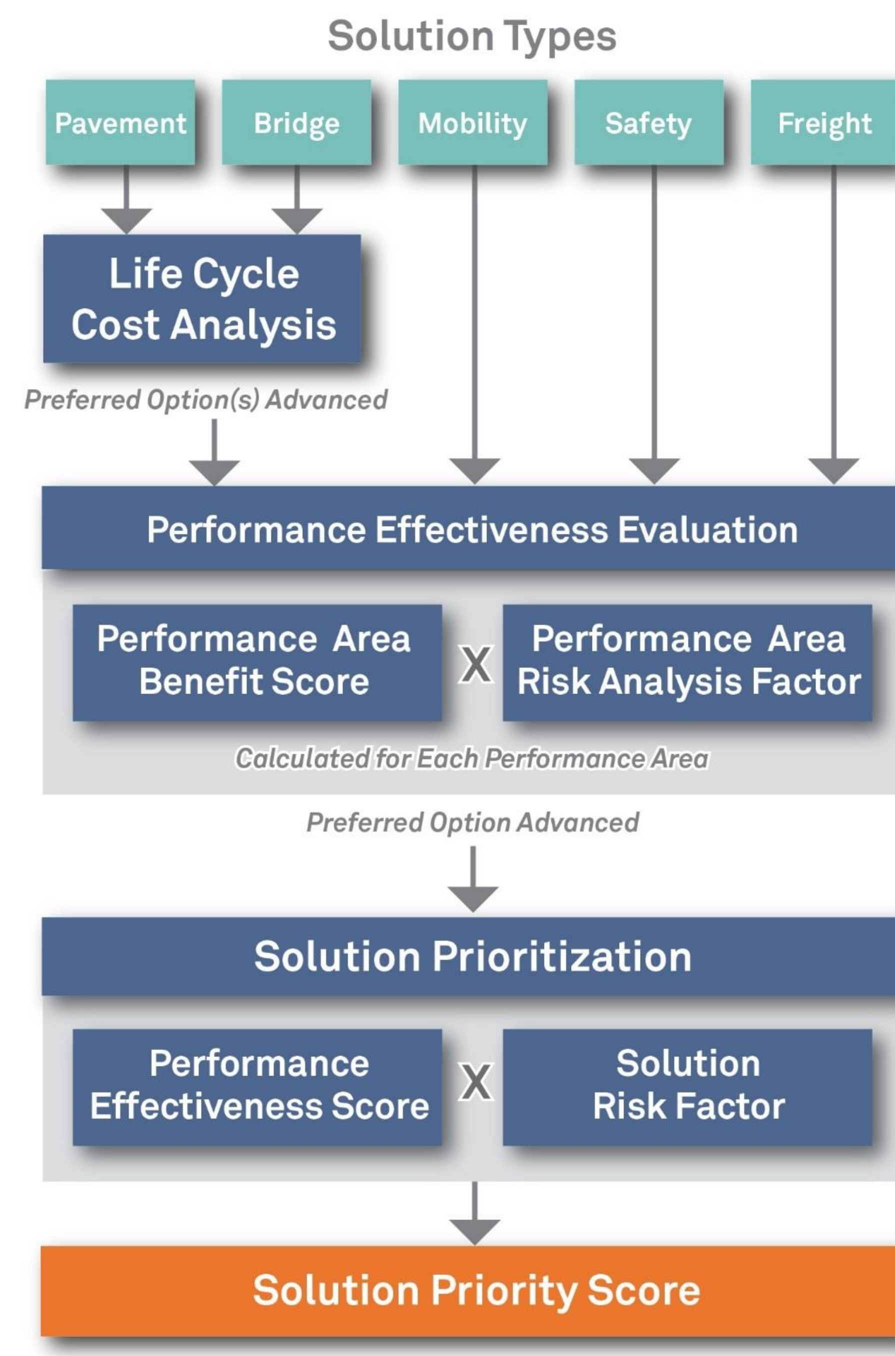
Solution Risk Analysis

All candidate solutions advanced through the Performance Effectiveness Evaluation are also evaluated through a Solution Risk Analysis process. A solution risk probability and consequence analysis is conducted to develop a solution-level risk weighting factor. This risk analysis is a numeric scoring system to help address the risk of not implementing a solution based on the likelihood and severity of performance failure.

Candidate Solution Prioritization

The PES, weighted risk factor, and segment average need score are combined to create a prioritization score. The candidate solutions are ranked by prioritization score from highest to lowest. The highest prioritization score indicates the candidate solution that is recommended as the highest priority. Solutions that address multiple performance areas tend to score higher in this process.

Figure 10: Candidate Solution Evaluation Process



5.1 Life-Cycle Cost Analysis

LCCA is conducted for any candidate solution that is developed as a result of a need in the Pavement or Bridge performance area. The intent of the LCCA is to determine which options warrant further investigation and eliminate options that would not be considered strategic.

LCCA is an economic analysis that compares cost streams over time and presents the results in a common measure, the present value of all future costs. The cost stream occurs over an analysis period that is long enough to provide a reasonably fair comparison among alternatives that may differ significantly in scale of improvement actions over shorter time periods. For both bridge and pavement LCCA, the costs are focused on agency (ADOT) costs for corrective actions to meet the objective of keeping the bridge or pavement serviceable over a long period of time.

LCCA is performed to provide a more complete holistic perspective on asset performance and agency costs over the life of an investment stream. This approach helps ADOT look beyond initial and short-term costs, which often dominate the considerations in transportation investment decision making and programming.

Bridge LCCA

For the bridge LCCA, three basic strategies are analyzed that differ in timing and scale of improvement actions to maintain the selected bridges, as described below:

- Bridge replacement (large upfront cost but small ongoing costs afterwards)
- Bridge rehabilitation until replacement (moderate upfront costs then small to moderate ongoing costs until replacement)
- On-going repairs until replacement (low upfront and ongoing costs until replacement)

The bridge LCCA model developed for the CPS reviews the characteristics of the candidate bridges including bridge ratings and deterioration rates to develop the three improvement strategies (full replacement, rehabilitation until replacement, and repair until replacement). Each strategy consists of a set of corrective actions that contribute to keeping the bridge serviceable over the analysis period. Cost and effect of these improvement actions on the bridge condition are essential parts of the model. Other considerations in the model include bridge age, elevation, pier height, length-to-span ratio, skew angle, and substandard characteristics such as shoulders and vehicle clearance. The following assumptions are included in the bridge LCCA model:

- The bridge LCCA only addresses the structural condition of the bridge and does not address other issues or costs
- The bridge will require replacement at the end of its 75-year service life regardless of current condition
- The bridge elevation, pier height, skew angle, and length-to-span ratio can affect the replacement and rehabilitation costs
- The current and historical ratings are used to estimate a rate of deterioration for each candidate bridge
- Following bridge replacement, repairs will be needed every 20 years
- Different bridge repair and rehabilitation strategies have different costs, expected service life, and benefit to the bridge rating
- The net present value of future costs is discounted at 3% and all dollar amounts are in 2015 dollars
- If the LCCA evaluation recommends rehabilitation or repair, the solution is not considered strategic and the rehabilitation or repair will be addressed by normal programming processes
- Because this LCCA is conducted at a planning level, and due to the variabilities in costs and improvement strategies, the LCCA net present value results that are within 15% should be considered equally; in such a case, the solution should be carried forward as a strategic replacement project – more detailed scoping will confirm if replacement or rehabilitation is needed

Based on the candidate solutions presented in **Table 6**, LCCA was not conducted for any bridges on the SR 179/SR 89A/SR 260 corridor, as noted in **Table 7**. Additional information regarding the bridge LCCA is included in **Appendix E**.

Pavement LCCA

The LCCA approach to pavement is very similar to the process used for bridges. For the pavement LCCA, three basic strategies are analyzed that differ in timing and scale of improvement actions to maintain the selected pavement, as described below:

- Pavement replacement (large upfront cost but small ongoing costs afterwards – could be replacement with asphalt or concrete pavement)
- Pavement major rehabilitation until replacement (moderate upfront costs then small to moderate ongoing costs until replacement)
- Pavement minor rehabilitation until replacement (low upfront and ongoing costs until replacement)

The pavement LCCA model developed for the CPS reviews the characteristics of the candidate paving locations including the historical rehabilitation frequency to develop potential improvement strategies (full replacement, major rehabilitation until replacement, and minor rehabilitation until replacement, for either concrete or asphalt, as applicable). Each strategy consists of a set of corrective actions that contribute to keeping the pavement serviceable over the analysis period. The following assumptions are included in the pavement LCCA model:

- The pavement LCCA only addresses the condition of the pavement and does not address other issues or costs
- The historical pavement rehabilitation frequencies at each location are used to estimate future rehabilitation frequencies
- Different pavement replacement and rehabilitation strategies have different costs and expected service life

- The net present value of future costs is discounted at 3% and all dollar amounts are in 2015 dollars
- If the LCCA evaluation recommends rehabilitation or repair, the solution is not considered strategic and the rehabilitation will be addressed by normal programming processes
- Because this LCCA is conducted at a planning level, and due to the variabilities in costs and improvement strategies, the LCCA net present value results that are within 15% should be considered equally; in such a case, the solution should be carried forward as a strategic replacement project – more detailed scoping will confirm if replacement or rehabilitation is needed

Based on the candidate solutions presented in **Table 6**, LCCA was not conducted for any pavement sections on the SR 179/SR 89A/SR 260 corridor, as noted in **Table 8**. Additional information regarding the pavement LCCA is contained in **Appendix E**.

Table 7: Bridge Life-Cycle Cost Analysis Results

Candidate Solution	Present Value at 3% Discount Rate ($)			Ratio of Present Value Compared to Lowest Present Value			Other Needs	Results
	Replace	Rehab	Repair	Replace	Rehab	Repair		
No LCCA conducted for any bridge candidate solution on the SR 179/SR 89A/SR 260 corridor								

Table 8: Pavement Life-Cycle Cost Analysis Results

Candidate Solution	Present Value at 3% Discount Rate ($)				Ratio of Present Value Compared to Lowest Present Value				Other Needs	Results
	Concrete Reconstruction	Asphalt Reconstruction	Asphalt Medium Rehabilitation	Asphalt Light Rehabilitation	Concrete Reconstruction	Asphalt Reconstruction	Asphalt Medium Rehabilitation	Asphalt Light Rehabilitation		
No LCCA conducted for any pavement candidate solutions on the SR 179/SR 89A/SR 260 corridor										

5.2 Performance Effectiveness Evaluation

The results of the Performance Effectiveness Evaluation are combined with the results of a Performance Area Risk Analysis to determine a PES as defined in Section 5.0. The objectives of the Performance Effectiveness Evaluation include:

- Measure the benefit to the performance system versus the cost of the solution
- Include risk factors to help differentiate between similar solutions
- Apply to each performance area that is affected by the candidate solution
- Account for emphasis areas identified for the corridor

The Performance Effectiveness Evaluation includes the following steps:

- Estimate the post-solution performance for each of the five performance areas (Pavement, Bridge, Mobility, Safety, and Freight)
- Use the post-solution performance scores to calculate a post-solution level of need for each of the five performance areas
- Compare the pre-solution level of need to the post-solution level of need to determine the reduction in level of need (potential solution benefit) for each of the five performance areas
- Calculate performance area risk weighting factors for each of the five performance areas
- Use the reduction in level of need (benefit) and risk weighting factors to calculate the PES

Post-Solution Performance Estimation

For each performance area, a slightly different approach is used to estimate the post-solution performance. This process is based on the following assumptions:

- Pavement:
  - The IRI rating would decrease (to 30 for replacement or 45 for rehabilitation)
  - The Cracking rating would decrease (to 0 for replacement or rehabilitation)
- Bridge:
  - The structural ratings would increase (+1 for repair, +2 for rehabilitation, or increase to 8 for replacement)
  - The Sufficiency Rating would increase (+10 for repair, +20 for rehabilitation, or increase to 98 for replacement)
- Mobility:
  - Additional lanes would increase the capacity and therefore affect the Mobility Index and associated secondary measures
  - Other improvements (e.g., ramp metering, parallel ramps, variable speed limits) would also increase the capacity (to a lesser extent than additional lanes) and therefore would affect the Mobility Index and associated secondary measures
  - Changes in the Mobility Index (due to increased capacity) would have a direct effect on the TTI secondary measure
  - Changes in the Mobility Index (due to increased capacity) and Safety Index (due to crash reductions) would have a direct effect on the PTI secondary measure
  - Changes in the Safety Index (due to crash reductions) would have a direct effect on the Closure Extent secondary measure
- Safety:
  - Crash modification factors were developed that would be applied to estimate the reduction in crashes (for additional information see **Appendix F**)
- Freight:
  - Changes in the Mobility Index (due to increased capacity) and Safety Index (due to crash reductions) would have a direct effect on the Freight Index and the TPTI secondary measure
  - Changes in the Mobility Index (due to increased capacity) would have a direct effect on the TTTI secondary measure
  - Changes in the Safety Index (due to crash reductions) would have a direct effect on the Closure Duration secondary measure

Performance Area Risk Analysis

The Performance Area Risk Analysis is intended to develop a numeric risk weighting factor for each of the five performance areas (Pavement, Bridge, Mobility, Safety, and Freight). This risk analysis addresses other considerations for each performance area that are not directly included in the performance system. A risk weighting factor is calculated for each candidate solution based on the specific characteristics at the solution location. For example, the Pavement Risk Factor is based on factors such as the elevation, daily traffic volumes, and amount of truck traffic. Additional information regarding the Performance Area Risk Factors is included in **Appendix G**.

Following the calculation of the reduction in level of need (benefit) and the Performance Area Risk Factors, these values are used to calculate the PES. In addition, the reduction in level of need in each emphasis area is also included in the PES.

Net Present Value Factor

The benefit (reduction in need) is measured as a one-time benefit. However, different types of solutions will have varying service lives during which the benefits will be obtained. For example, a preservation solution would likely have a shorter stream of benefits over time when compared to a modernization or expansion solution. To address the varying lengths of benefit streams, each solution is classified as a 10-year, 20-year, 30-year, or 75-year benefit stream, or the net present value (NPV) factor (F_{NPV}). A 3% discount rate is used to calculate F_{NPV} for each classification of solution. The service lives and respective factors are described below:

- A 10-year service life is generally reflective of preservation solutions such as pavement and bridge preservation; these solutions would likely have a 10-year stream of benefits; for these solutions, a F_{NPV} of 8.8 is used in the PES calculation

- A 20-year service life is generally reflective of modernization solutions that do not include new infrastructure; these solutions would likely have a 20-year stream of benefits; for these solutions, a F_{NPV} of 15.3 is used in the PES calculation
- A 30-year service life is generally reflective of expansion solutions or modernization solutions that include new infrastructure; these solutions would likely have a 30-year stream of benefits; for these solutions, a F_{NPV} of 20.2 is used in the PES calculation
- A 75-year service life is used for bridge replacement solutions; these solutions would likely have a 75-year stream of benefits; for these solutions, a F_{NPV} of 30.6 is used in the PES calculation

Vehicle-Miles Travelled Factor

Another factor in assessing benefits is the number of travelers who would benefit from the implementation of the candidate solution. This factor varies between candidate solutions depending on the length of the solution and the magnitude of daily traffic volumes. Multiplying the solution length by the daily traffic volume results in vehicle-miles travelled (VMT), which provides a measure of the amount of traffic exposure that would receive the benefit of the proposed solution. The VMT is converted to a VMT factor (known as F_{VMT}), which is on a scale between 0 and 5, using the equation below:

$$F_{VMT} = 5 - (5 \times e^{VMT \times -0.0000139})$$

Performance Effectiveness Score

The PES is calculated using the following equation:

PES = ((Sum of all Risk Factored Benefit Scores + Sum of all Risk Factored Emphasis Area Scores) / Cost) x F_{VMT} x F_{NPV}

Where:

Risk Factored Benefit Score = Reduction in Segment-Level Need (benefit) x Performance Area Risk Weighting Factor (calculated for each performance area)

Risk Factored Emphasis Area Score = Reduction in Corridor-Level Need x Performance Area Risk Factors x Emphasis Area Factor (calculated for each emphasis area)

*Cost = estimated cost of candidate solution in millions of dollars (see **Appendix H**)*

F_{VMT} = Factor between 0 and 5 to account for VMT at location of candidate solution based on existing (2014) daily volume and length of solution

F_{NPV} = Factor (ranging from 8.8 to 30.6 as previously described) to address anticipated longevity of service life (and duration of benefits) for each candidate solution

The resulting PES values are shown in **Table 9**. Additional information regarding the calculation of the PES is contained in **Appendix I**.

For candidate solutions with multiple options to address Mobility, Safety, or Freight needs, the PES should be compared to help identify the best performing option. If one option clearly performs better than the other options (e.g., more than twice the PES value and a difference in magnitude of at least 20 points), the other options can be eliminated from further consideration. If multiple options have similar PES values, or there are other factors not accounted for in the performance system that could significantly influence the ultimate selection of an option (e.g., potential environmental concerns, potential adverse economic impacts), those options should all be advanced to the prioritization process. On the SR 179/SR 89A/SR 260 corridor, no candidate solutions have options to address needs.

Table 9: Performance Effectiveness Scores

Candidate Solution #	Segment #	Option	Candidate Solution Name	Milepost Location	Estimated Cost* (in millions)	Risk Factored Benefit Score					Risk Factored Emphasis Area Scores			Total Factored Benefit Score	F_{VMT}	F_{NPV}	Performance Effectiveness Score
						Pavement	Bridge	Mobility	Safety	Freight	Mobility	Safety	Freight				
CS179.1	179-2	-	SR 179 Hillside Area Mobility and Freight Improvements	313-314	$8.9	1.77	0.00	8.83	0.00	9.83	1.28	0.00	1.95	23.66	1.46	20.2	78.7
CS89A.2	89A-3	-	West Sedona Area Safety, Mobility, and Freight Improvements	370-374	$4.9	0.00	0.00	8.05	8.73	0.55	0.00	0.88	0.57	18.78	3.30	20.2	257.8
CS89A.3	89A-3	-	Page Springs Road Intersection Area Safety Improvements	356-369	$8.0	0.00	0.00	0.36	7.81	1.24	0.00	2.86	0.00	12.27	1.23	15.3	29.0
CS89A/260.4	89A-4	-	Cottonwood Area Safety and Freight Improvements	356-209	$3.1	0.00	0.00	0.72	11.02	0.30	0.00	1.19	0.20	13.43	3.50	15.3	235.1

*: See Table 11 for total construction costs

5.3 Solution Risk Analysis

Following the calculation of the PES, an additional step is taken to develop the prioritized list of solutions. A solution risk probability and consequence analysis is conducted to develop a solution-level risk weighting factor. This risk analysis is a numeric scoring system to help address the risk of not implementing a solution based on the likelihood and severity of performance failure. **Figure 11** shows the risk matrix used to develop the risk weighting factors.

Figure 11: Risk Matrix

Frequency/ Likelihood		Severity/Consequence				
		Insignificant	**Minor**	**Significant**	**Major**	**Catastrophic**
	Very Rare	Low	Low	Low	Moderate	Major
	Rare	Low	Low	Moderate	Major	Major
	Seldom	Low	Moderate	Moderate	Major	Severe
	Common	Moderate	Moderate	Major	Severe	Severe
	Frequent	Moderate	Major	Severe	Severe	Severe

Using the risk matrix in **Figure 11**, numeric values were assigned to each category of frequency and severity. The higher the risk, the higher the numeric factor that was assigned. The risk weight for each area of the matrix was calculated by multiplying the severity factor times the frequency factor. These numeric factors are shown in **Figure 12**.

Figure 12: Numeric Risk Matrix

Frequency/ Likelihood			Severity/Consequence				
			Insignificant	**Minor**	**Significant**	**Major**	**Catastrophic**
		Weight	1.00	1.10	1.20	1.30	1.40
	Very Rare	1.00	1.00	1.10	1.20	1.30	1.40
	Rare	1.10	1.10	1.21	1.32	1.43	1.54
	Seldom	1.20	1.20	1.32	1.44	1.56	1.68
	Common	1.30	1.30	1.43	1.56	1.69	1.82
	Frequent	1.40	1.40	1.54	1.68	1.82	1.96

Using the values in **Figure 12**, risk weighting factors were calculated for each of the following four risk categories: low, moderate, major, and severe. These values are simply the average of the values in **Figure 12** that fall within each category. The resulting average risk weighting factors are:

Low	Moderate	Major	Severe
1.14	1.36	1.51	1.78

The risk weighting factors listed above are assigned to the five performance areas as follows:

- Safety = 1.78
  - The Safety performance area quantifies the likelihood of fatal or incapacitating injury crashes; therefore, it is assigned the Severe (1.78) risk weighting factor
- Bridge = 1.51
  - The Bridge performance area focuses on the structural adequacy of bridges; a bridge failure may result in crashes or traffic being detoured for long periods of time resulting in significant travel time increases; therefore, it is assigned the Major (1.51) risk weighting factor
- Mobility and Freight = 1.36
  - The Mobility and Freight performance areas focus on capacity and congestion; failure in either of these performance areas would result in increased travel times but would not have significant effect on safety (crashes) that would not already be addressed in the Safety performance area; therefore, they are assigned the Moderate (1.36) risk weighing factor
- Pavement = 1.14
  - The Pavement performance area focuses on the ride quality of the pavement; failure in this performance area would likely be a spot location that would not dramatically affect drivers beyond what is already captured in the Safety performance area; therefore, it is assigned the Low (1.14) risk weighting factor

The benefit in each performance area is calculated for each candidate solution as part of the Performance Effectiveness Evaluation. Using this information on benefits and the risk factors listed above, a weighted (based on benefit) solution-level numeric risk factor is calculated for each candidate solution. For example, a solution that has 50% of its benefit in Safety and 50% of its benefit in Mobility has a weighted risk factor of 1.57 (0.50 x 1.36 + 0.50 x 1.78 = 1.57).

5.4 Candidate Solution Prioritization

The PES, weighted risk factor, and segment average need score are combined to create a prioritization score as follows:

Prioritization Score = PES x Weighted Risk Factor x Segment Average Need Score

Where:

PES = Performance Effectiveness Score as shown in ***Table 9***

Weighted Risk Factor = Weighted factor to address risk of not implementing a solution based on the likelihood and severity of the performance failure

Segment Average Need Score = Segment average need score as shown in ***Table 4***

Table 10 shows the prioritization scores for the candidate solutions subjected to the solution evaluation and prioritization process. Solutions that address multiple performance areas tend to score higher in this process. A prioritized list of candidate solutions is provided in the subsequent section. See **Appendix J** for additional information on the prioritization process.

Table 10: Prioritization Scores

Candidate Solution #	Segment #	Option	Candidate Solution Name	Milepost Location	Estimated Cost (in millions)	Performance Effectiveness Score	Weighted Risk Factor	Segment Average Need Score	Prioritization Score	Percentage by which Solution Reduces Performance Area Segment Needs				
										Pavement	Bridge	Mobility	Safety	Freight
CS179.1	179-2	-	SR 179 Hillside Area Mobility and Freight Improvements	313-314	$8.9	70.8	1.30	1.46	**135**	74%	0%	40%	0%	2%
CS89A.2	89A-3	-	West Sedona Area Safety, Mobility, and Freight Improvements	370-374	$4.9	257.8	1.58	1.85	**750**	0%	0%	40%	43%	4%
CS89A.3	89A-3	-	Page Springs Road Intersection Area Safety Improvements	356-369	$8.0	29.0	1.73	1.38	**69**	0%	0%	12%	43%	27%
CS89A/260.4	89A-4	-	Cottonwood Area Safety and Freight Improvements	356-209	$3.1	235.1	1.74	1.38	**567**	0%	0%	13%	33%	4%

6.0 SUMMARY OF CORRIDOR RECOMMENDATIONS

6.1 Prioritized Candidate Solution Recommendations

Table 11 and **Figure 13** show the prioritized candidate solutions recommended for the SR 179/SR 89A/SR 260 corridor in ranked order of priority. The highest prioritization score indicates the candidate solution that is recommended as the highest priority. Implementation of these solutions is anticipated to improve performance of the SR 179/SR 89A/SR 260 corridor. The following observations were noted about the prioritized solutions:

- Most of the anticipated improvements in performance are in the Mobility, Safety, and Freight performance areas
- The highest ranking solutions tend to have overlapping benefits in the Mobility, Safety, and Freight performance areas
- The highest priority solutions address needs in the Rye area (SR 87 MP 235-241), Salt River area (SR 87 MP 177-182) and near the Payson area (SR 87 MP 246-251)

6.2 Other Corridor Recommendations

As part of the investigation of strategic investment areas and candidate solutions, other corridor recommendations can also be identified. These recommendations could include modifications to the existing Statewide Construction Program, areas for further study, or other corridor-specific recommendations that are not related to construction or policy. The list below identifies other corridor recommendations for the SR 179/SR 89A/SR 260 corridor:

- Support the City of Sedona efforts to implement improvements on SR 179 and SR 89A as proposed in the City's Transportation Master Plan, including:
  - Construct bicycle boulevard on north side of SR 89A, MP 369-374
  - Implement a shuttle system for the corridor with park-and-ride lots located along routes
  - Implement a travel time information system for the corridor (including DMS, CCTV, etc.)
  - Conduct an access management plan for the West Sedona area of the corridor
- Conduct an intersection performance study at SR 89A/SR 260 intersection in Cottonwood
- Conduct an access management plan for the Cottonwood area of the corridor

6.3 Policy and Initiative Recommendations

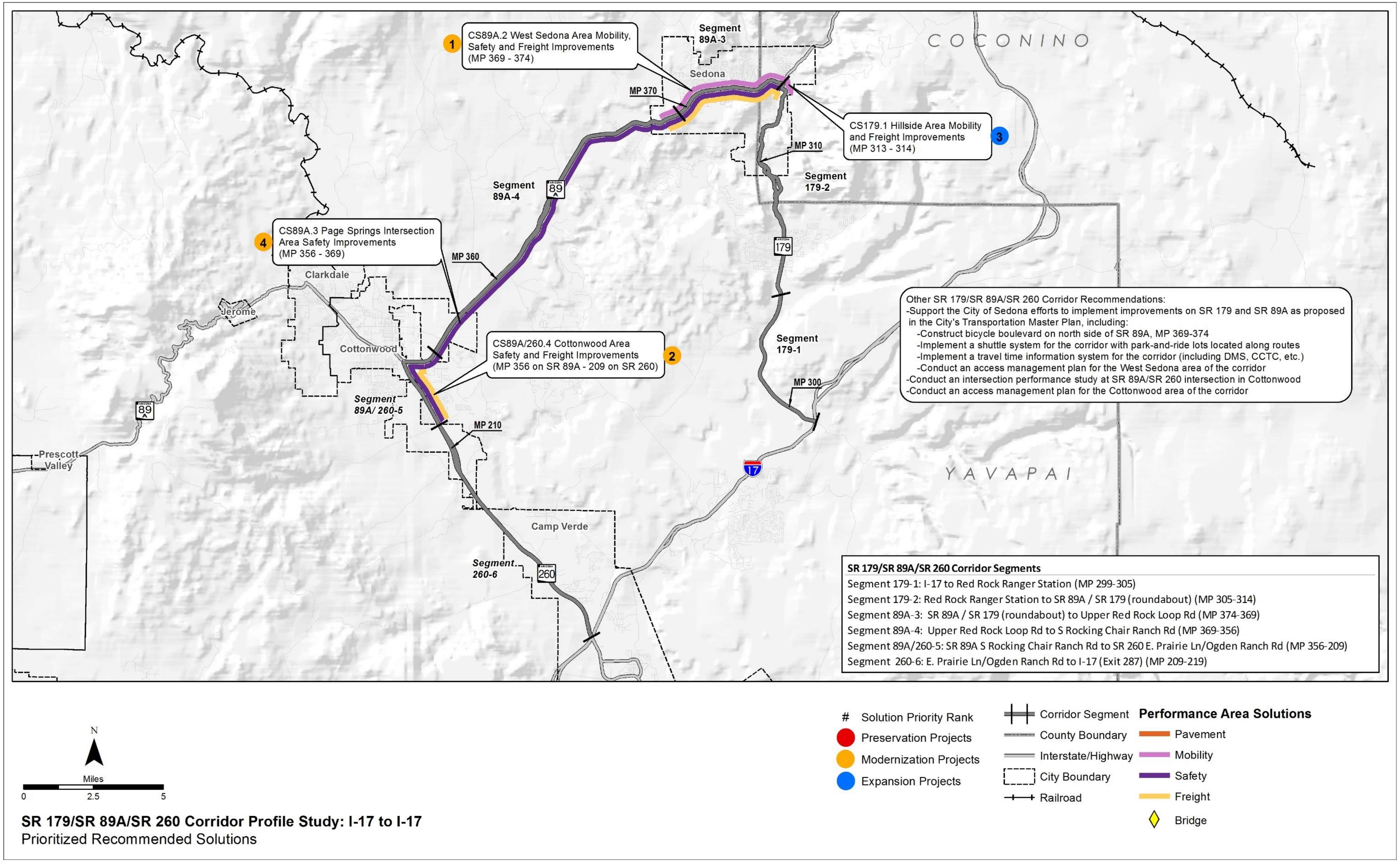
In addition to location-specific needs, general corridor and system-wide needs have also been identified through the CPS process. While these needs are more overarching and cannot be individually evaluated through this process, it is important to document them. A list of recommended policies and initiatives was developed for consideration when programming future projects not only on SR 179/SR 89A/SR 260, but across the entire state highway system where the conditions are applicable. The following list, which is in no particular order of priority, was derived from the Round 1, Round 2, and Round 3 CPS:

- Install Intelligent Transportation System (ITS) conduit with all new infrastructure projects
- Prepare strategic plans for Closed Circuit Television (CCTV) camera and Road Weather Information System (RWIS) locations statewide
- Leverage power and communication at existing weigh-in-motion (WIM), dynamic message signs (DMS), and call box locations to expand ITS applications across the state
- Consider solar power for lighting and ITS where applicable
- Investigate ice formation prediction technology where applicable
- Conduct highway safety manual evaluation for all future programmed projects
- Develop infrastructure maintenance and preservation plans (including schedule and funding) for all pavement and bridge infrastructure replacement or expansion projects
- Develop standardized bridge maintenance procedures so districts can do routine maintenance work
- Review historical ratings and level of previous investment during scoping of pavement and bridge projects. In pavement locations that warrant further investigation, conduct subsurface investigations during project scoping to determine if full replacement is warranted
- For pavement rehabilitation projects, enhance the amount/level of geotechnical investigations to address issues specific to the varying conditions along the project
- Expand programmed and future pavement projects as necessary to include shoulders
- Expand median cable barrier guidelines to account for safety performance
- Install CCTV cameras with all DMS
- In locations with limited communications, use CCTV cameras to provide still images rather than streaming video
- Develop statewide program for pavement replacement
- Install additional continuous permanent count stations along strategic corridors to enhance traffic count data
- When reconstruction or rehabilitation activities will affect existing bridge vertical clearance, the dimension of the new bridge vertical clearance should be a minimum of 16.25 feet where feasible
- All new or reconstructed roadway/shoulder edges adjacent to an unpaved surface should be constructed with a Safety Edge
- Collision data on tribal lands may be incomplete or inconsistent; additional coordination for data on tribal lands is required to ensure adequate reflection of safety issues
- Expand data collection devices statewide to measure freight delay
- Evaluate and accommodate potential changes in freight and goods movement trends that may result from improvements and expansions to the state roadway network

Table 11: Prioritized Recommended Solutions

Rank	Candidate Solution #	Option	Solution Name and Location	Description / Scope	Estimated Cost (in millions)	Investment Category (Preservation [P], Modernization [M], Expansion [E])	Prioritization Score
1	CS89A.2	-	West Sedona Area Safety, Mobility, and Freight Improvements (MP 369-374)	-Construct continuous raised median between MP 370.5 and MP 374.0 -Implement signal communication, coordination, and adaptive traffic control from Upper Red Rock Loop Rd (MP 369.6) to Airport Rd (MP 373.1), a total of 8 signals	$4.9	M	750
2	CS89A/260.4	-	Cottonwood Area Safety and Freight Improvements (MP 356 on SR 89A-MP 209 on SR 260)	-Install lighting and raised median at Rio Mesa Trail intersection, MP 207.2 -Improve signal visibility at Western Drive intersection, MP 208.8 -Construct continuous raised median, MP 208-209 -Implement signal communication, coordination and adaptive traffic control on SR 260/SR 89A from Cornville Road (MP 357.1 on SR 89A) to Western Drive (MP 208.8 on SR 260), total of 7 signals	$3.1	M	567
3	CS179.1	-	SR 179 Hillside Area Mobility and Freight Improvements (MP 313-314)	-Expand Schnebly Hill Road roundabout to 2 lanes (MP 313.1) -Widen to 4 lanes between Schnebly Hill Road (MP 313.0) roundabout and SR 179/SR 89A roundabout (the “Y”) (MP 313.4) -Construct a pedestrian tunnel or bridge at Tlaquepaque, replacing the existing crosswalk -Construct separated right-turn lane towards SB SR 179 and separated right-turn lane towards Uptown at SR 179/SR 89A roundabout (the “Y”) (MP 313.4)	$8.9	E	135
4	CS89A.3	-	Page Springs Road Intersection Area Safety Improvements (MP 356-369)	-Intersection reconstruction, MP 362.5 (Page Springs Road) -Rehabilitate shoulders in both directions (striping, delineators, RPMs, safety edge, and rumble strips for both shoulders), MP 356.5-369.6 -Install chevrons, curve warning signs with beacons, and speed reduced ahead signs, MP 368.2-369.0 -Install speed feedback signs approaching curves, SB MP 369 and NB MP 368 -Install chevrons and curve warning signs with beacons either side of curve at MP 366	$8.0	M	69

Figure 13: Prioritized Recommended Solutions



6.4 Next Steps

The candidate solutions recommended in this study are not intended to be a substitute or replacement for traditional ADOT project development processes where various ADOT technical groups and districts develop candidate projects for consideration in the performance-based programming in the P2P process. Rather, these candidate solutions are intended to complement ADOT's traditional project development processes through a performance-based process to address needs in one or more of the five performance areas of Pavement, Bridge, Mobility, Safety, and Freight. Candidate solutions developed for the SR 179/SR 89A/SR 260 corridor will be considered along with other candidate projects in the ADOT statewide programming process.

It is important to note that the candidate solutions are intended to represent strategic solutions to address existing performance needs related to the Pavement, Bridge, Mobility, Safety, and Freight performance areas. Therefore, the strategic solutions are not intended to preclude recommendations related to the ultimate vision for the corridor that may have been defined in the context of prior planning studies and/or design concept reports. Recommendations from such studies are still relevant to addressing the ultimate corridor objectives.

Upon completion of all four CPS rounds, the results will be incorporated into a summary document comparing all corridors that is expected to provide a performance-based review of statewide needs and candidate solutions.

Appendix A: Corridor Performance Maps

Appendix A was provided in the previously submitted Draft Report: Performance and Needs Evaluation

Appendix B: Performance Area Detailed Calculation Methodologies

Appendix B was provided in the previously submitted Draft Report: Performance and Needs Evaluation

Appendix C: Performance Area Data

Appendix C was provided in the previously submitted Draft Report: Performance and Needs Evaluation

Appendix D: Needs Analysis Contributing Factors and Scores

Appendix D was provided in the previously submitted Draft Report: Performance and Needs Evaluation

Appendix E: Life-Cycle Cost Analysis

No LCCA conducted for any Pavement or Bridge candidate solutions on the SR 179/SR 89A/SR 260 North corridor

Appendix F: Crash Modification Factors and Factored Unit Construction Costs

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
REHABILITATION							
Rehabilitate Pavement (AC)	$276,500	Mile	2.20	$610,000	Mill and replace 1"-3" AC pavement; accounts for 38' width; for one direction of travel on two-lane roadway; includes pavement, striping, delineators, RPMs, rumble strips	0.70	Combination of rehabilitate pavement (0.92), striping, delineators, RPMs (0.77 for combination), and rumble strips (0.89) = 0.70
Rehabilitate Bridge	$65	SF	2.20	$140	Based on deck area; bridge only - no other costs included	0.95	Assumed - should have a minor effect on crashes at the bridge
GEOMETRIC IMPROVEMENT							
Re-profile Roadway	$974,500	Mile	2.20	$2,140,000	Includes excavation of approximately 3", pavement replacement (AC), striping, delineators, RPMs, rumble strips, for one direction of travel on two-lane roadway (38' width)	0.70	Assumed - this is similar to rehab pavement. This solution is intended to address vertical clearance at bridge, not profile issue; factor the cost as a ratio of needed depth to 3".
Realign Roadway	$2,960,000	Mile	2.20	$6,510,000	All costs per direction except bridges; applicable to areas with small or moderate fills and cuts, minimal retaining walls	0.50	Based on Caltrans and NCDOT
Improve Skid Resistance	$675,000	Mile	2.20	$1,490,000	Average cost of pavement replacement and variable depth paving to increase super-elevation; for one direction of travel on two-lane roadway; includes pavement, striping, delineators, RPMs, rumble strips	0.66	Combination of average of 5 values from clearinghouse (0.77) and calculated value from HSM (0.87) for skid resistance; striping, delineators, RPMs (0.77 for combination), and rumble strips (0.89) = 0.66
INFRASTRUCTURE IMPROVEMENT							
Reconstruct to Urban Section	$1,000,000	Mile	2.20	$2,200,000	Includes widening by 16' total (AC = 12'+2'+2') to provide median, curb & gutter along both side of roadway, single curb for median, striping (doesn't include widening for additional travel lane).	0.88	From HSM
Construct Auxiliary Lanes (AC)	$914,000	Mile	2.20	$2,011,000	For addition of aux lane (AC) in one direction of travel; includes all costs except bridges; for generally at-grade facility with minimal walls and no major drainage improvements	0.78	Average of 4 values from clearinghouse
Construct Climbing Lane (High)	$3,000,000	Mile	2.20	$6,600,000	In one direction; all costs except bridges; applicable to areas with large fills and cuts, retaining walls, rock blasting, steep slopes on both sides of road	0.75	From HSM

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
Construct Climbing Lane (Medium)	$2,250,000	Mile	2.20	$4,950,000	In one direction; all costs except bridges; applicable to areas with medium or large fills and cuts, retaining walls, rock blasting, steep slopes on one side of road	0.75	From HSM
Construct Climbing Lane (Low)	$1,500,000	Mile	2.20	$3,300,000	In one direction; all costs except bridges; applicable to areas with small or moderate fills and cuts, minimal retaining walls	0.75	From HSM
Construct Reversible Lane (Low)	$2,400,000	Lane-Mile	2.20	$5,280,000	All costs except bridges; applicable to areas with small or moderate fills and cuts, minimal retaining walls	0.73 for uphill and 0.88 for downhill	Based on proposed conditions on I-17 with 2 reversible lanes and a concrete barrier
Construct Reversible Lane (High)	$4,800,000	Lane-Mile	2.20	$10,560,000	All costs except bridges; applicable to areas with large fills and cuts, retaining walls, rock blasting, mountainous terrain	0.73 for uphill and 0.88 for downhill	Based on proposed conditions on I-17 with 2 reversible lanes and a concrete barrier
Construct Passing Lane	$1,500,000	Mile	2.20	$3,300,000	In one direction; all costs except bridges; applicable to areas with small or moderate fills and cuts, minimal retaining walls	0.63	Average of 3 values from clearinghouse
Construct Entry/Exit Ramp	$730,000	Each	2.20	$1,610,000	Cost per ramp; includes pavement, striping, signing, RPMs, lighting, typical earthwork & drainage; does not include any major structures or improvements on crossroad	1.09	Average of 16 values on clearinghouse; for adding a ramp not reconstructing. CMF applied to crashes 0.25 miles upstream/downstream from the gore.
Relocate Entry/Exit Ramp	$765,000	Each	2.20	$1,680,000	Cost per ramp; includes pavement, striping, signing, RPMs, lighting, typical earthwork, drainage and demolition of existing ramp; does not include any major structures or improvements on crossroad	1.00	Assumed to not add any crashes since the ramp is simply moving and not being added. CMF applied to crashes 0.25 miles upstream/downstream from the gore.
Construct Turn Lanes	$42,500	Each	2.20	$93,500	Includes 14' roadway widening (AC) for one additional turn lane (250' long) on one leg of an intersection; includes AC pavement, curb & gutter, sidewalk, ramps, striping, and minor signal modifications	0.81	Average of 7 values from HSM; CMF applied to intersection related crashes; this solution also applies when installing a deceleration lane
Modify Entry/Exit Ramp	$445,000	Each	2.20	$979,000	Cost per ramp; includes pavement, striping, signing, RPMs, lighting, minor earthwork, & drainage; For converting existing ramp to parallel-type configuration	0.21	Average of 4 values from clearinghouse (for exit ramps) and equation from HSM (for entrance ramp). CMF applied to crashes within 1/8 mile upstream/downstream from the gore.
Widen & Modify Entry/Exit Ramp	$619,000	Each	2.20	$1,361,800	Cost per ramp; includes pavement, striping, signing, RPMs, lighting, minor earthwork, & drainage; For converting 1-lane ramp to 2-lane ramp and converting to parallel-type ramp	0.21	Will be same as "Modify Ramp"

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
Replace Pavement (AC) (with overexcavation)	$1,446,500	Mile	2.20	$3,180,000	Accounts for 38' width; for one direction of travel on two-lane roadway; includes pavement, overexcavation, striping, delineators, RPMs, rumble strips	0.70	Same as rehab
Replace Pavement (PCCP) (with overexcavation)	$1,736,500	Mile	2.20	$3,820,000	Accounts for 38' width; for one direction of travel on two-lane roadway; includes pavement, overexcavation, striping, delineators, RPMs, rumble strips	0.70	Same as rehab
Replace Bridge (Short)	$125	SF	2.20	$280	Based on deck area; bridge only - no other costs included; cost developed generally applies to bridges crossing small washes	0.95	Assumed - should have a minor effect on crashes at the bridge
Replace Bridge (Medium)	$160	SF	2.20	$350	Based on deck area; bridge only - no other costs included; cost developed generally applies to bridges crossing over the mainline freeway, crossroads, or large washes	0.95	Assumed - should have a minor effect on crashes at the bridge
Replace Bridge (Long)	$180	SF	2.20	$400	Based on deck area; bridge only - no other costs included; cost developed generally applies to bridges crossing large rivers or canyons	0.95	Assumed - should have a minor effect on crashes at the bridge
Widen Bridge	$175	SF	2.20	$390	Based on deck area; bridge only - no other costs included	0.90	Assumed - should have a minor effect on crashes at the bridge
Install Pedestrian Bridge	$135	SF	2.20	$300	Includes cost to construct bridge based on linear feet of the bridge. This cost includes and assumes ramps and sidewalks leading to the structure.	0.1 (pedestrian only)	Assumed direct access on both sides of structure
Implement Automated Bridge De-icing	$115	SF	2.20	$250	Includes cost to replace bridge deck and install system	0.72 (snow/ice)	Average of 3 values on clearinghouse for snow/ice
Install Wildlife Crossing Under Roadway	$650,000	Each	2.20	$1,430,000	Includes cost of structure for wildlife crossing under roadway and 1 mile of fencing in each direction that is centered on the wildlife crossing	0.25 (wildlife)	Assumed; CMF applies to wildlife-related crashes within 0.5 miles both upstream and downstream of the wildlife crossing in both directions
Install Wildlife Crossing Over Roadway	$1,140,000	Each	2.20	$2,508,000	Includes cost of structure for wildlife crossing over roadway and 1 mile of fencing in each direction that is centered on the wildlife crossing	0.25 (wildlife)	Assumed; CMF applies to wildlife-related crashes within 0.5 miles both upstream and downstream of the wildlife crossing in both directions
Construct Drainage Structure - Minor	$280,000	Each	2.20	$616,000	Includes 3-36" pipes and roadway reconstruction (approx. 1,000 ft) to install pipes	0.70	Same as rehab; CMF applied to crashes 1/8 mile upstream/downstream of the structure
Construct Drainage Structure - Intermediate	$540,000	Each	2.20	$1,188,000	Includes 5 barrel 8'x6' RCBC and roadway reconstruction (approx. 1,000 ft) to install RCBC	0.70	Same as rehab; CMF applied to crashes 1/8 mile upstream/downstream of the structure

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
Construct Drainage Structure - Major	$8,000	LF	2.20	$17,600	Includes bridge that is 40' wide and reconstruction of approx. 500' on each approach	0.70	Same as rehab; CMF applied to crashes 1/8 mile upstream/downstream of the structure
Install Acceleration Lane	$127,500	Each	2.20	$280,500	For addition of an acceleration lane (AC) on one leg of an intersection that is 1,000' long plus a taper; includes all costs except bridges; for generally at-grade facility with minimal walls and no major drainage improvements	0.85	Average of 6 values from the FHWA Desktop Reference for Crash Reduction Factors
OPERATIONAL IMPROVEMENT							
Implement Variable Speed Limits (Wireless, Overhead)	$718,900	Mile	2.20	$1,580,000	In one direction; includes 1 sign assembly per mile (foundation and structure), wireless communication, detectors	0.92	From 1 value from clearinghouse
Implement Variable Speed Limits (Wireless, Ground-mount)	$169,700	Mile	2.20	$373,300	In one direction; includes 2 signs per mile (foundations and posts), wireless communication, detectors	0.92	From 1 value from clearinghouse
Implement Variable Speed Limits (Wireless, Solar, Overhead)	$502,300	Mile	2.20	$1,110,000	In one direction; includes 1 sign assembly per mile (foundation and structure), wireless communication, detectors, solar power	0.92	From 1 value from clearinghouse
Implement Variable Speed Limits (Wireless, Solar, Ground-mount)	$88,400	Mile	2.20	$194,500	In one direction; includes 2 signs per mile (foundations and posts), wireless communication, detectors, solar power	0.92	From 1 value from clearinghouse
Implement Ramp Metering (Low)	$25,000	Each	2.20	$55,000	For each entry ramp location; urban area with existing ITS backbone infrastructure; includes signals, poles, timer, pull boxes, etc.	0.64	From 1 value from clearinghouse; CMF applied to crashes 0.25 miles after gore
Implement Ramp Metering (High)	$150,000	Mile	2.20	$330,000	Area without existing ITS backbone infrastructure; in addition to ramp meters, also includes conduit, fiber optic lines, and power	0.64	From 1 value from clearinghouse
Implement Signal Coordination	$140,000	Mile	2.20	$308,000	Includes conduit, conductors, and controllers for 4 intersections that span a total of approximately 2 miles	0.90	Assumed

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
Implement Left-Turn Phasing	$7,500	Each	2.20	$16,500	Includes four new signal heads (two in each direction) and associated conductors for one intersection	0.88 (protected) 0.98 (permitted/protected or protected/permitted)	From HSM; CMF = 0.94 for each protected approach and 0.99 for each permitted/protected or protected/permitted approach. CMFs of different approaches should be multiplied together. CMF applied to crashes within intersection
ROADSIDE DESIGN							
Install Guardrail	$130,000	Mile	2.20	$286,000	One side of road	0.62 (ROR)	0.62 is average of 2 values from clearinghouse
Install Cable Barrier	$80,000	Mile	2.20	$176,000	In median	0.81	0.81 is average of 5 values from clearinghouse
Widen Shoulder (AC)	$256,000	Mile	2.20	$563,000	Assumes 10' of existing shoulder (combined left and right), includes widening shoulder by a total of 4'; new pavement for 4' width and mill and replace existing 10' width; includes pavement, minor earthwork, striping edge lines, RPMs, high-visibility delineators, safety edge, and rumble strips	0.68 (1-4') 0.64 (>= 4')	0.86 is average of 5 values from clearing house for widening shoulder 1-4'. 0.76 is calculated from HSM for widening shoulder >= 4'. (Cost needs to be updated if dimension of existing and widened shoulder differ from Description.)
Rehabilitate Shoulder (AC)	$113,000	Mile	2.20	$249,000	One direction of travel (14' total shoulder width-4' left and 10' right); includes paving (mill and replace), striping, high-visibility delineators, RPMs, safety edge, and rumble strips for both shoulders	0.72	0.98 is average of 34 values on clearinghouse for shoulder rehab/replace; include striping, delineators, RPMs (0.77 combined CMF), and rumble strips (0.89). (Cost needs to be updated if dimension of existing shoulder differs from Description.)
Replace Shoulder (AC)	$364,000	Mile	2.20	$801,000	One direction of travel (14' total shoulder width-4' left and 10' right); includes paving (full reconstruction), striping, high-visibility delineators, RPMs, safety edge, and rumble strips for both shoulders	0.72	0.98 is average of 34 values on clearinghouse for shoulder rehab/replace; include striping, delineators, RPMs (0.77 combined CMF), and rumble strips (0.89). (Cost needs to be updated if dimension of existing shoulder differs from Description.)
Install Rumble Strip	$5,500	Mile	2.20	$12,000	Both edges - one direction of travel; includes only rumble strip; no shoulder rehab or paving or striping	0.89	Average of 75 values on clearinghouse and consistent with HSM
Install Centerline Rumble Strip	$2,800	Mile	2.20	$6,000	Includes rumble strip only; no pavement rehab or striping	0.85	From HSM

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
Install Wildlife Fencing	$340,000	Mile	2.20	$748,000	Fencing only plus jump outs for 1 mile (both directions)	0.50 (wildlife)	Assumed
Remove Tree/Vegetation	$200,000	Mile	2.20	$440,000	Intended for removing trees that shade the roadway to allow sunlight to help melt snow and ice (see Increase Clear Zone CMF for general tree/vegetation removal in clear zone)	0.72 (snow/ice)	Average of 3 values on clearinghouse for snow/ice
Increase Clear Zone	$59,000	Mile	2.20	$130,000	In one direction; includes widening the clear zone by 10' to a depth of 3'	0.71	Median of 14 values from FHWA Desktop Reference for Crash Reduction Values
Install Access Barrier Fence	$15	LF	2.20	$33	8' fencing along residential section of roadway	0.10 (pedestrian only)	Equal to pedestrian overpass
Install Rock-Fall Mitigation - Wire Mesh	$1,320,000	Mile	2.20	$2,904,000	Includes wire mesh and rock stabilization (one direction)	0.75 (debris)	Assumed
Install Rock-Fall Mitigation - Containment Fence & Barrier	$2,112,000	Mile	2.20	$4,646,000	Includes containment fencing, concrete barrier, and rock stabilization (one direction)	0.75 (debris)	Assumed
Install Raised Concrete Barrier in Median	$650,000	Mile	2.20	$1,430,000	Includes concrete barrier with associated striping and reflective markings; excludes lighting in barrier (one direction)	0.90 (Cross-median and head on crashes eliminated completely)	All cross median and head-on fatal or incapacitating injury crashes are eliminated completely; all remaining crashes have 0.90 applied
Formalize Pullout (Small)	$7,500	Each	2.20	$17,000	Includes paving and signage (signs, posts, and foundations) - approximately 4,200 sf	0.97	Assumed - similar to Install Other General Warning Signs; CMF applied to crashes within 0.25 miles after sign
Formalize Pullout (Medium)	$27,500	Each	2.20	$61,000	Includes paving and signage (signs, posts, and foundations) - approximately 22,500 sf	0.97	Assumed - similar to Install Other General Warning Signs; CMF applied to crashes within 0.25 miles after sign
Formalize Pullout (Large)	$80,500	Each	2.20	$177,100	Includes paving and signage (signs, posts, and foundations) - approximately 70,000 sf	0.97	Assumed - similar to Install Other General Warning Signs; CMF applied to crashes within 0.25 miles after sign
INTERSECTION IMPROVEMENTS							
Construct Traffic Signal	$150,000	Each	2.20	$330,000	4-legged intersection; includes poles, foundations, conduit, controller, heads, luminaires, mast arms, etc.	0.95	From HSM; CMF applied to crashes within intersection only
Improve Signal Visibility	$35,000	Each	2.20	$77,000	4-legged intersection; signal head size upgrade, installation of new back-plates, and installation of additional signal heads on new poles.	0.85	Average of 7 values from clearinghouse; CMF applied to crashes within intersection only

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
Install Raised Median	$360,000	Mile	2.20	$792,000	Includes removal of 14' wide pavement and construction of curb & gutter; does not include cost to widen roadway to accommodate the median; if the roadway needs to be widened, include cost from New General Purpose Lane	0.83	Average from HSM
Install Transverse Rumble Strip/Pavement Markings	$3,000	Each	2.20	$7,000	Includes pedestrian markings and rumble strips only across a 30' wide travelway; no pavement rehab or other striping	0.95	Average of 17 values from clearinghouse; CMF applied to crashes within 0.5 miles after the rumble strips and markings
Construct Single-Lane Roundabout	$1,500,000	Each	2.20	$3,300,000	Removal of signal at 4-legged intersection; realignment of each leg for approx. 800 feet including paving, curbs, sidewalk, striping, lighting, signing	0.22	From HSM; CMF applied to crashes within intersection only
Construct Double-Lane Roundabout	$1,800,000	Each	2.20	$3,960,000	Removal of signal at 4-legged intersection; realignment of each leg for approx. 800 feet including paving, curbs, sidewalk, striping, lighting, signing	0.40	From HSM; CMF applied to crashes within intersection only
ROADWAY DELINEATION							
Install High-Visibility Edge Line Striping	$10,800	Mile	2.20	$23,800	2 edge lines and lane line - one direction of travel	0.77	Average of 3 values from clearinghouse. Assumes package of striping, delineators, and RPMs. (If implemented separately, CMF will be higher.)
Install High-Visibility Delineators	$6,500	Mile	2.20	$14,300	Both edges - one direction of travel		Average of 3 values from clearinghouse. Assumes package of striping, delineators, and RPMs. (If implemented separately, CMF will be higher.)
Install Raised Pavement Markers	$2,000	Mile	2.20	$4,400	Both edges - one direction of travel		Average of 3 values from clearinghouse. Assumes package of striping, delineators, and RPMs. (If implemented separately, CMF will be higher.)
Install In-Lane Route Markings	$6,000	Each	2.20	$13,200	Installation of a series of three in-lane route markings in one lane	0.95	Assumed; CMF applied to crashes within 1.0 mile before the gore

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
IMPROVED VISIBILITY							
Cut Side Slopes	$80	LF	2.20	$200	For small grading to correct sight distance issues; not major grading	0.85	Intent of this solution is to improve sight distance. Most CMF's are associated with vehicles traveling on slope. Recommended CMF is based on FDOT and NCDOT but is more conservative.
Install Lighting (connect to existing power)	$270,000	Mile	2.20	$594,000	One side of road only; offset lighting, not high-mast; does not include power supply; includes poles, luminaire, pull boxes, conduit, conductor	0.75 (night)	Average of 3 values on clearinghouse & consistent with HSM
Install Lighting (solar powered LED)	$10,000	Pole	2.20	$22,000	Offset lighting, not high-mast; solar power LED; includes poles, luminaire, solar panel	0.75 (night)	Average of 3 values on clearinghouse & consistent with HSM
DRIVER INFORMATION/WARNING							
Install Dynamic Message Sign (DMS)	$250,000	Each	2.20	$550,000	Includes sign, overhead structure, and foundations; wireless communication; does not include power supply	1.00	Not expected to reduce crashes
Install Dynamic Weather Warning Beacons	$40,000	Each	2.20	$88,000	Assumes solar operation and wireless communication or connection to existing power and communication; ground mounted; includes posts, foundations, solar panel, and dynamic sign	0.80 (weather related)	Average of 3 values from FHWA Desktop Reference for Crash Reduction Factors; CMF applies to crashes within 0.25 miles after a sign
Install Dynamic Speed Feedback Signs	$25,000	Each	2.20	$55,000	Assumes solar operation and no communication; ground mounted; includes regulatory sign, posts, foundations, solar panel, and dynamic sign	0.94	Average of 2 clearinghouse values; CMF applies to crashes within 0.50 miles after a sign
Install Chevrons	$18,400	Mile	2.20	$40,500	On one side of road - includes signs, posts, and foundations	0.79	Average of 11 clearinghouse values
Install Curve Warning Signs	$2,500	Each	2.20	$5,500	Includes 2 signs, posts, and foundations	0.83	Average of 4 clearinghouse values; CMF applies to crashes within 0.25 miles after a sign
Install Traffic Control Device Warning Signs (e.g., stop sign ahead, signal ahead, etc.)	$2,500	Each	2.20	$5,500	Includes 2 signs, posts, and foundations	0.85	FHWA Desktop Reference for Crash Reduction Factors; CMF applies to crashes within 0.25 miles after a sign
Install Other General Warning Signs (e.g., intersection ahead, wildlife in area, slow vehicles, etc.)	$2,500	Each	2.20	$5,500	Includes 2 signs, posts, and foundations	0.97	Assumed; CMF applies to crashes within 0.25 miles after a sign

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
Install Wildlife Warning System	$162,000	Each	2.20	$356,400	Includes wildlife detection system at a designated wildlife crossing, flashing warning signs (assumes solar power), advance signing, CCTV (solar and wireless), game fencing for approximately 0.25 miles in each direction - centered on the wildlife crossing, and regular fencing for 1.0 mile in each direction - centered on the wildlife crossing.	0.50 (wildlife)	Assumed; CMF applies to wildlife-related crashes within 0.5 miles both upstream and downstream of the wildlife crossing in both directions
Install Warning Sign with Beacons	$15,000	Each	2.20	$33,000	In both directions; includes warning sign, post, and foundation, and flashing beacons (assumes solar power) at one location	0.75	FHWA Desktop Reference for Crash Reduction Factors for Installing Flashing Beacons as Advance Warning; CMF applies to crashes within 0.25 miles after a sign
Install Larger Stop Sign with Beacons	$10,000	Each	2.20	$22,000	In one direction; includes large stop sign, post, and foundation, and flashing beacons (assumes solar power) at one location	0.85/0.81	Use 0.85 for adding beacons to an existing sign; 0.81 for installing a larger sign with flashing beacons; CMF applies to intersection related crashes
DATA COLLECTION							
Install Roadside Weather Information System (RWIS)	$60,000	Each	2.20	$132,000	Assumes wireless communication and solar power, or connection to existing power and communications	1.00	Not expected to reduce crashes
Install Closed Circuit Television (CCTV) Camera	$25,000	Each	2.20	$55,000	Assumes connection to existing ITS backbone or wireless communication; does not include fiber-optic backbone infrastructure; includes pole, camera, etc.	1.00	Not expected to reduce crashes
Install Vehicle Detection Stations	$15,000	Each	2.20	$33,000	Assumes wireless communication and solar power, or connection to existing power and communications	1.00	Not expected to reduce crashes
Install Flood Sensors (Activation)	$15,000	Each	2.20	$33,000	Sensors with activation cabinet to alert through texting (agency)	1.00	Not expected to reduce crashes
Install Flood Sensors (Gates)	$100,000	Each	2.20	$220,000	Sensors with activation cabinet to alert through texting (agency) and beacons (public) plus gates	1.00	Not expected to reduce crashes
WIDEN CORRIDOR							
Construct New General Purpose Lane (PCCP)	$1,740,000	Mile	2.20	$3,830,000	For addition of 1 GP lane (PCCP) in one direction; includes all costs except bridges; for generally at-grade facility with minimal walls and no major drainage improvements	0.90	North Carolina DOT uses 0.90 and Florida DOT uses 0.87

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
Construct New General Purpose Lane (AC)	$1,200,000	Mile	2.20	$2,640,000	For addition of 1 GP lane (AC) in one direction; includes all costs except bridges; for generally at-grade facility with minimal walls and no major drainage improvements	0.90	North Carolina DOT uses 0.90 and Florida DOT uses 0.88
Convert a 2-Lane undivided highway to a 5-Lane highway	$1,576,000	Mile	2.20	$3,467,200	For expanding a 2-lane undivided highway to a 5-lane highway (4 through lanes with TWLTL), includes standard shoulder widths but no curb, gutter, or sidewalks	0.60	Assumed to be slightly lower than converting from a 4-lane to a 5-lane highway
Install Center Turn Lane	$1,053,000	Mile	2.20	$2,316,600	For adding a center turn lane (i.e., TWLTL); assumes symmetrical widening on both sides of the road; includes standard shoulder widths but no curb, gutter, or sidewalk	0.75	From FHWA Desktop Reference for Crash Reduction Factors, CMF Clearinghouse, and SR 87 CPS comparison
Construct 4-Lane Divided Highway (Using Existing 2-Lane Road for one direction)	$3,000,000	Mile	2.20	$6,600,000	In both directions; one direction uses existing 2-lane road; other direction assumes addition of 2 new lanes (AC) with standard shoulders; includes all costs except bridges	0.67	Assumed
Construct 4-Lane Divided Highway (No Use of Existing Roads)	$6,000,000	Mile	2.20	$13,200,000	In both directions; assumes addition of 2 new lanes (AC) with standard shoulders in each direction; includes all costs except bridges	0.67	Assumed
Construct Bridge over At-Grade Railroad Crossing	$10,000,000	Each	2.20	$22,000,000	Assumes bridge width of 4 lanes (AC) with standard shoulders; includes abutments and bridge approaches; assumes vertical clearance of 23'4" + 6'8" superstructure	0.72 (All train-related crashes eliminated)	Removes all train-related crashes at at-grade crossing; all other crashes CMF = 0.72
Construct Underpass at At-Grade Railroad Crossing	$15,000,000	Each	2.20	$33,000,000	Assumes underpass width of 4 lanes (AC) with standard shoulders; includes railroad bridge with abutments and underpass approaches; assumes vertical clearance of 16'6" + 6'6" superstructure	0.72 (All train-related crashes eliminated)	Removes all train-related crashes at at-grade crossing; all other crashes CMF = 0.72
Construct High-Occupancy Vehicle (HOV) Lane	$900,000	Mile	2.20	$1,980,000	For addition of 1 HOV lane (AC) in one direction with associated signage and markings; includes all costs except bridges; for generally at-grade facility with minimal walls and no major drainage improvements	0.95	Similar to general purpose lane

SOLUTION	CONSTRUCTION UNIT COST	UNIT	FACTOR^	FACTORED CONSTRUCTION UNIT COST	DESCRIPTION	CMF FOR CORRIDOR PROFILE STUDIES	CMF NOTES
ALTERNATE ROUTE							
Construct Frontage Roads	$2,400,000	Mile	2.20	$5,280,000	For 2-lane AC frontage road; includes all costs except bridges; for generally at-grade facility with minimal walls	0.90	Assumed - similar to new general purpose lane
Construct 2-Lane Undivided Highway	$3,000,000	Mile	2.20	$6,600,000	In both directions; assumes addition of 2 new lanes (AC) with standard shoulders in each direction; includes all costs except bridges	0.90	Assuming new alignment for a bypass
OTHER IMPROVEMENTS							
Install Curb and Gutter	$211,200	Mile	2.20	$465,000	In both directions; curb and gutter	0.89	From CMF Clearinghouse
Install Sidewalks, Curb, and Gutter	$475,200	Mile	2.20	$1,045,000	In both directions; 5' sidewalks, curb, and gutter	0.89 installing sidewalk 0.24 (pedestrian crashes only)	From CMF Clearinghouse Average of 6 values from FHWA Desktop Reference
Install Sidewalks	$264,000	Mile	2.20	$581,000	In both directions; 5' sidewalks	0.24 (pedestrian crashes only)	Average of 6 values from FHWA Desktop Reference
Install Advanced Warning Signal System	$108,000	each	2.20	$238,000	Overhead static sign with flashing beacons, detectors, and radar system. Signs for each mainline approach of the intersection (2)	0.61	FHWA Desktop Reference for CRF
Install Indirect Left Turn Intersection	$1,140,000	each	2.20	$2,500,000	Raised concrete median improvements; intersection improvements; turn lanes	0.80	CMF Clearinghouse
Convert Standard Diamond Interchange to Diverging Diamond Interchange	$2,272,700	each	2.20	$5,000,000	Convert traditional diamond interchange into diverging diamond interchange; assumes re-use of existing bridges	0.67	CMF Clearinghouse
Install Adaptive Signal Control and Signal Coordination	$363,500	mile	2.20	$800,000	Controller upgrades, advanced detection, software configuration, cameras; includes conduit, conductors, and controllers for 4 intersections that span a total of approximately 2 miles for coordination	0.81 (adaptive control) 0.90 (signal coordination)	CMF Clearinghouse
Left-in Only Center Raised Median Improvements	$84,100	each	2.20	$185,000	Left-in only center raised median improvements	0.87	CMF Clearinghouse

^ Factor accounts for traffic control, erosion control, construction surveying and quality control, mobilization, construction engineering, contingencies, indirect cost allocation, and miscellaneous work

Appendix G: Performance Area Risk Factors

Pavement Performance Area

- Elevation
- Mainline Daily Traffic Volume
- Mainline Daily Truck Volume

Elevation

Variance above 4000' divided by 1000; (Elev-4000)/1000

Score	Condition
0	< 4000'
0-5	4000'- 9000'
5	> 9000'

Mainline Daily Traffic Volume

Exponential equation; score = $5-(5*e^{(ADT*-0.000039)})$

Score	Condition
0	< 6,000
0-5	6,000 – 160,000
5	>160,000

Mainline Daily Truck Volume

Exponential equation; score = $5-(5*e^{(ADT*-0.00025)})$

Score	Condition
0	<900
0-5	900-25,000
5	>25,000

Bridge Performance Area

- Mainline Daily Traffic Volume
- Elevation
- Carries Mainline Traffic
- Detour Length
- Scour Critical Rating
- Vertical Clearance

Mainline Daily Traffic Volume

Exponential equation; score = $5-(5*e^{(ADT*-0.000039)})$

Score	Condition
0	<6,000
0-5	6,000-160,000
5	>160,000

Elevation

Variance above 4000' divided by 1000; (Elev-4000)/1000

Score	Condition
0	< 4000'
0-5	4000'- 9000'
5	> 9000'

Carries Mainline Traffic

Score	Condition
0	Does not carry mainline traffic
5	Carries mainline traffic

Detour Length

Divides detour length by 10 and multiplies by 2.5

Score	Condition
0	0 miles
0-5	0-20 miles
5	> 20 miles

Scour Critical Rating

Variance below 8

Score	Condition
0	Rating > 8
0-5	Rating 8 - 3
5	Rating < 3

Vertical Clearance

Variance below 16' x 2.5; (16 –Clearance) x 2.5

Score	Condition
0	>16'
0-5	16'-14'
5	<14'

Mobility Performance Area

- Mainline VMT
- Buffer Index (PTI-TTI)
- Detour Length
- Outside Shoulder Width

Mainline VMT

Exponential equation; score = 5-(5*e(ADT*-0.0000139))

Score	Condition
0	<16,000
0-5	16,000-400,000
5	>400,000

Buffer Index

Buffer Index x 10

Score	Condition
0	Buffer Index = 0.00
0-5	Buffer Index 0.00-0.50
5	Buffer Index > 0.50

Detour Length

Score	Condition
0	Detour < 10 miles
5	Detour > 10 miles

Outside Shoulder Width

Variance below 10’, if only 1 lane in each direction

Score	Condition
0	10’ or above or >1 lane in each direction
0-5	10’-5’ and 1 lane in each direction
5	5’ or less and 1 lane in each direction

Safety Performance Area

- Mainline Daily Traffic Volume
- Interrupted Flow
- Elevation
- Outside Shoulder Width
- Vertical Grade

Mainline Daily Traffic Volume

Exponential equation; score = 5-(5*e$^{(ADT*-0.000039)}$)

Score	Condition
0	<6,000
0-5	6,000-160,000
5	>160,000

Interrupted Flow

Score	Condition
0	Not interrupted flow
5	Interrupted Flow

Elevation

Variance above 4000' divided by 1000; (Elev-4000)/1000

Score	Condition
0	< 4000’
0-5	4000’- 9000’
5	> 9000’

Outside Shoulder Width

Variance below 10'

Score	Condition
0	10’ or above
0-5	10’ - 5’
5	5’ or less

Grade

Variance above 3% x 1.5

Score	Condition
0	< 3%
0-5	3% - 6.33%
5	>6.33%

Freight Performance Area

- Mainline Daily Truck Volume
- Detour Length
- Truck Buffer Index (TPTI-TTTI)
- Outside Shoulder Width

Mainline Daily Truck Volume

Exponential equation; score = 5-(5*e$^{(ADT*-0.00025)}$)

Score	Condition
0	<900
0-5	900-25,000
5	>25,000

Detour Length

Score	Condition
0	Detour < 10 miles
5	Detour > 10 miles

Truck Buffer Index

Truck Buffer Index x 10

Score	Condition
0	Buffer Index = 0.00
0-5	Buffer Index 0.00-0.50
5	Buffer Index > 0.50

Outside Shoulder Width

Variance below 10’, if only 1 lane in each direction

Score	Condition
0	10’ or above or >1 lane in each direction
0-5	10’-5’ and 1 lane in each direction
5	5’ or less and 1 lane in each direction

Solution Number	Mainline Traffic Vol (vpd) (2-way)	Solution Length (miles)	Bridge Detour Length (miles) (N19)	Elevation (ft)	Scour Critical Rating (0-9)	Carries Mainline Traffic (Y/N)	Bridge Vert. Clear (ft)	Mainline Truck Vol (vpd) (2-way)	Detour Length > 10 miles (Y/N)	Truck Buffer Index	Non-Truck Buffer Index	Grade (%)	Interrupted Flow (Y/N)	Outside/ Right Shoulder Width (ft)	1-lane each direction
CS179.1	16604	3.5		4,200				492	Y	3.57	2.58	3.3	Y	4	Y
CS89A.2	22,225	3.5		4,400				917	Y	5.44	4.99	2.5	Y	4.4	N
CS89A.3	13,965	1.45		4,000				846	Y	2.54	1.45	3.5	Y	10	N
CS89A/260.4	22,244	3.89		3,400				1,250	N	5.87	2.87	2.0	Y	2	N

Solution Number	Bridge	Pavement	Mobility	Safety	Freight	Risk Score (0 to 10)				
						Bridge	Pavement	Mobility	Safety	Freight
CS179.1	N	Y	Y	Y	Y	0.00	2.10	7.38	5.21	6.66
CS89A.2	N	N	Y	Y	Y	0.00	0.00	6.07	5.31	5.11
CS89A.3	N	N	Y	Y	Y	0.00	0.00	3.67	3.13	3.96
CS89A/260.4	N	N	Y	Y	Y	0.00	0.00	2.85	5.15	2.94

Appendix H: Candidate Solution Cost Estimates

Candidate Solution #	Location #	Candidate Solution Name	Scope	BMP	EMP	Unit	Quantity	Factored Construction Unit Cost	Preliminary Engineering Cost	Design Cost	Right-of-Way Cost	Construction Cost	Total Cost	Notes
CS179.1	L3/L4	SR 179 Hillside Area Mobility and Freight Improvements	Expand Schnebly Hill Road roundabout to 2 lanes	313.1		each	1.0	$4,555,000	$137,000	$456,000	$250,000	$4,555,000	$5,398,000	
			Widen to 4 lanes between Schnebly Hill Road roundabout and SR 179/SR 89A roundabout (the "Y")	313.0	313.4	mi	0.4	$239,084	$3,000	$10,000	$0	$95,634	$109,000	
			Construct a pedestrian tunnel or bridge at Tlaquepaque, replacing the existing crosswalk	313.2		each	1.0	$1,771,698	$53,000	$177,000	$0	$1,771,698	$2,002,000	
			Construct separated right-turn lane towards SB SR 179 and separated right-turn lane towards Uptown at SR 179/SR 89A roundabout (the "Y")	313.4		each	2.0	$501,018	$30,000	$100,000	$250,000	$1,002,036	$1,382,000	
			Solution Total						**$223,000**	**$743,000**	**$500,000**	**$7,424,368**	**$8,891,000**	
CS89A.2	L5/L6/L7	West Sedona Area Safety, Mobility, and Freight Improvements	Install raised median	370.5	374	mi	3.5	$792,000	$83,000	$277,000	$0	$2,772,000	$3,132,000	
			Implement signal communication, coordination, and adaptive traffic control from Upper Red Rock Loop Road to Airport Road, 8 signals	369.6	373.1	each	1.0	$1,531,000	$46,000	$153,000	$0	$1,531,000	$1,730,000	Factored Construction Unit Cost altered to reflect a total of 8 signals over 3.5 miles See detailed cost backup developed for this solution in separate spreadsheet.
			Solution Total						**$129,000**	**$430,000**	**$0**	**$4,303,000**	**$4,862,000**	

Candidate Solution #	Location #	Candidate Solution Name	Scope	BMP	EMP	Unit	Quantity	Factored Construction Unit Cost	Preliminary Engineering Cost	Design Cost	Right-of-Way Cost	Construction Cost	Total Cost	Notes
CS89A.3	L11	Page Springs Road Intersection Area Safety Improvements	Reconstruct Intersection, US 89A/Page Springs Road (work includes relocating the SB left-turn lane, removal of pavement, new pavement for a two-way crossing, and additional signage)	362.5		each	1.0	$187,900	$6,000	$19,000	$0	$187,900	$212,900	See detailed cost backup developed for this solution in separate spreadsheet.
			Rehabilitate Shoulders, NB	356.5	369.6	mi	13.1	$249,000	$98,000	$327,000	$0	$3,271,860	$3,696,860	Rehab Shoulder cost altered to reflect existing conditions - 10 ft. outside and 4 ft. inside shoulder widths
			Rehabilitate Shoulders, SB	356.5	369.6	mi	13.1	$249,000	$98,000	$327,000	$0	$3,271,860	$3,696,860	Rehab Shoulder cost altered to reflect existing conditions - 10 ft. outside and 4 ft. inside shoulder widths
			Install chevrons, NB	368.2	369.0	mi	0.8	$40,500	$1,000	$3,000	$0	$32,400	$36,400	
			Install chevrons, SB	368.2	369.0	mi	0.8	$40,500	$1,000	$3,000	$0	$32,400	$36,400	
			Install curve warning signs with flashing beacons	368.5		each	2.0	$33,000	$2,000	$7,000	$0	$66,000	$75,000	NB/SB approaches into curves
			Install speed reduced ahead signs	368.5		each	2.0	$5,500	$300	$1,000	$0	$11,000	$12,300	NB/SB approaching intersection
			Install speed feedback signs, SB	369.0		each	1.0	$55,000	$2,000	$6,000	$0	$55,000	$63,000	Approaching curves
			Install speed feedback signs, NB	368.0		each	1.0	$55,000	$2,000	$6,000	$0	$55,000	$63,000	Approaching curves
			Install chevrons, NB	365.65	366.15	mi	0.5	$40,500	$1,000	$2,000	$0	$20,250	$23,250	
			Install chevrons, SB	365.65	366.15	mi	0.5	$40,500	$1,000	$2,000	$0	$20,250	$23,250	
			Install curve warning signs	366.0		each	2.0	$5,500	$300	$1,000	$0	$11,000	$12,300	NB/SB approaches into curve
								Solution Total	**$212,600**	**$704,000**	**$0**	**$7,034,920**	**$7,951,520**	

Candidate Solution #	Location #	Candidate Solution Name	Scope	BMP	EMP	Unit	Quantity	Factored Construction Unit Cost	Preliminary Engineering Cost	Design Cost	Right-of-Way Cost	Construction Cost	Total Cost	Notes
CS89A.4	L13	Cottonwood Area Safety and Freight Improvements	Implement signal communication, coordination, and adaptive traffic control from Cornville Road to Western Drive, 7 signals	357.1 on SR 89A	208.8 on SR 260	each	1.0	$1,480,000	$44,000	$148,000	$0	$1,480,000	$1,672,000	Factored Construction Unit Cost altered to reflect a total of 7 signals over 4.1 miles. See detailed cost backup developed for this solution in separate spreadsheet.
			Install lighting at Rio Mesa Trail intersection (1/8th of a mile either side of the intersection, both sides of the roadway)	207.2		mi	0.5	$594,000	$9,000	$30,000	$0	$297,000	$336,000	Connecting to existing power; quantity doubled to provide lighting on both sides of the roadway
			Install raised median	207.15	207.25	mi	0.10	$594,000	$2,000	$6,000	$0	$59,400	$67,400	
			Improve signal visibility, Western Drive	208.8		each	1	$77,000	$2,000	$8,000	$0	$77,000	$87,000	
			Install raised median	208.0	209.0	mi	1.0	$792,000	$24,000	$79,000	$0	$792,000	$895,000	
								Solution Total	**$81,000**	**$271,000**	**$0**	**$2,705,400**	**$3,057,400**	

Appendix I: Performance Effectiveness Scores

Need Reduction

LEGEND:
- -user entered value
- -calculated value for reference
- -calculated value for use in other spreadsheet
- -for input into PES spreadsheet
- -assumed values

Direction 1 = Clockwise (WB 260, NB 89A, SB 179)
Direction 2 = Counterclockwise (NB 179, SB 89A, EB 260)

		Solution #	CS179.1	CS89A.2	CS89A.3	CS89A.3	CS89A/260.4
		Description	SR 179 Hillside Area Mobility and Freight Improvements	West Sedona Area Safety, Mobility, and Freight Improvements	West Sedona Area Safety Improvements	Page Springs Road Intersection Area Safety Improvements	Cottonwood Area Safety and Freight Improvements
		Project Beg MP	313.1	369.64	370.5	356.5	356.5
		Project End MP	313.45	374	374	369.64	209.1
		Project Length (miles)	0.56	4.36	3.5	13.14	3.89
		Segment Beg MP	304.73	369.64	369	356.5	356.5
		Segment End MP	313.45	374.19	374	369.64	209.1
		Segment Length (miles)	8.72	4.55	5	13.14	3.89
		Segment #	179-2	89A-3	89A-3	89A-4	89A/260-5
		Current # of Lanes (both directions)	2	4	4	4	4
		Project Type (one-way or two-way)	two-way	two-way	two-way	two-way	two-way
		Additional Lanes (one-way)	1	0	0	0	0
		Pro-Rated # of Lanes	2.13	4.00	4.00	4.00	4.00
		Description					
SAFETY	DIRECTIONAL SAFETY	Orig Segment Directional Safety Index (direction 1)	0.791	0.115	0.115	0.978	4.237
SAFETY	DIRECTIONAL SAFETY	Orig Segment Directional Fatal Crashes (direction 1)	1	0	0	2	4
SAFETY	DIRECTIONAL SAFETY	Orig Segment Directional Incap Crashes (direction 1)	2	2	2	4	8
SAFETY	DIRECTIONAL SAFETY	Original Fatal Crashes in project limits (direction 1)	0	0	0	2	4
SAFETY	DIRECTIONAL SAFETY	Original Incap Crashes in project limits (direction 1)	0	2	2	4	8
SAFETY	DIRECTIONAL SAFETY	CMF 1 (direction 1)(lowest CMF)	1	Total CMF calculated in separate worksheet	0.83	Total CMF calculated in separate worksheet	Total CMF calculated in separate worksheet
SAFETY	DIRECTIONAL SAFETY	CMF 2 (direction 1)	1		1		
SAFETY	DIRECTIONAL SAFETY	CMF 3 (direction 1)	1		1		
SAFETY	DIRECTIONAL SAFETY	CMF 4 (direction 1)	1		1		
SAFETY	DIRECTIONAL SAFETY	CMF 5 (direction 1)	1		1		
SAFETY	DIRECTIONAL SAFETY	Total CMF (direction 1)	1.000	-	0.830	-	-
SAFETY	DIRECTIONAL SAFETY	Fatal Crash reduction (direction 1)	0.000	0.000	0.000	0.755	0.987
SAFETY	DIRECTIONAL SAFETY	Incap Crash reduction (direction 1)	0.000	0.592	0.340	1.129	2.325
SAFETY	DIRECTIONAL SAFETY	Post-Project Segment Directional Fatal Crashes (direction 1)	1.000	0.000	0.000	1.245	3.013
SAFETY	DIRECTIONAL SAFETY	Post-Project Segment Directional Incap Crashes (direction 1)	2.000	1.408	1.660	2.871	5.675
SAFETY	DIRECTIONAL SAFETY	Post-Project Segment Directional Safety Index (direction 1)	0.791	0.081	0.096	0.620	3.169
SAFETY	DIRECTIONAL SAFETY	Post-Project Segment Directional Safety Index (direction 1)	0.791	0.081	0.096	0.620	3.169
SAFETY	DIRECTIONAL SAFETY	Orig Segment Directional Safety Index (direction 2)	0.792	2.623	2.623	3.127	0.194
SAFETY	DIRECTIONAL SAFETY	Orig Segment Directional Fatal Crashes (direction 2)	1	3	3	7	0
SAFETY	DIRECTIONAL SAFETY	Orig Segment Directional Incap Crashes (direction 2)	2	2	2	5	3
SAFETY	DIRECTIONAL SAFETY	Original Fatal Crashes in project limits (direction 2)	0	2	3	7	0
SAFETY	DIRECTIONAL SAFETY	Original Incap Crashes in project limits (direction 2)	0	1	2	5	3
SAFETY	DIRECTIONAL SAFETY	CMF 1 (direction 2)(lowest CMF)	1	Total CMF calculated in separate worksheet	0.83	Total CMF calculated in separate worksheet	Total CMF calculated in separate worksheet
SAFETY	DIRECTIONAL SAFETY	CMF 2 (direction 2)	1		1		
SAFETY	DIRECTIONAL SAFETY	CMF 3 (direction 2)	1		1		
SAFETY	DIRECTIONAL SAFETY	CMF 4 (direction 2)	1		1		
SAFETY	DIRECTIONAL SAFETY	CMF 5 (direction 2)	1		1		
SAFETY	DIRECTIONAL SAFETY	Total CMF (direction 2)	1.000	-	0.830	-	-
SAFETY	DIRECTIONAL SAFETY	Fatal Crash reduction (direction 2)	0.000	0.762	0.510	2.156	0.000
SAFETY	DIRECTIONAL SAFETY	Incap Crash reduction (direction 2)	0.000	0.466	0.340	2.047	0.936
SAFETY	DIRECTIONAL SAFETY	Post-Project Segment Directional Fatal Crashes (direction 2)	1.000	2.238	2.490	4.844	0.000
SAFETY	DIRECTIONAL SAFETY	Post-Project Segment Directional Incap Crashes (direction 2)	2.000	1.534	1.660	2.953	2.064
SAFETY	DIRECTIONAL SAFETY	Post-Project Segment Directional Safety Index (direction 2)	0.792	1.959	2.177	2.149	0.134
SAFETY	DIRECTIONAL SAFETY	Post-Project Segment Directional Safety Index (direction 2)	0.792	1.959	2.177	2.149	0.134
SAFETY	SAFE TY INDE	Current Safety Index	0.792	1.369	1.369	2.052	2.215
SAFETY	SAFE TY INDE	Post-Project Safety Index	0.792	1.020	1.136	1.384	1.651
SAFETY	Needs	Original Segment Safety Need	0.616	3.792	3.792	5.832	6.501
SAFETY	Needs	Post-Project Segment Safety Need	No Change	2.148	2.807	3.341	4.363

LEGEND:
- -user entered value
- -calculated value for reference
- -calculated value for use in other spreadsheet
- -for input into PES spreadsheet
- -assumed values

Direction 1 = Clockwise (WB 260, NB 89A, SB 179)
Direction 2 = Counterclockwise (NB 179, SB 89A, EB 260)

Solution #	**CS179.1**	**CS89A.2**	**CS89A.3**	**CS89A.3**	**CS89A/260.4**
Description	SR 179 Hillside Area Mobility and Freight Improvements	West Sedona Area Safety, Mobility, and Freight Improvements	West Sedona Area Safety Improvements	Page Springs Road Intersection Area Safety Improvements	Cottonwood Area Safety and Freight Improvements
Project Beg MP	313.1	369.64	370.5	356.5	356.5
Project End MP	313.45	374	374	369.64	209.1
Project Length (miles)	0.56	4.36	3.5	13.14	3.89
Segment Beg MP	304.73	369.64	369	356.5	356.5
Segment End MP	313.45	374.19	374	369.64	209.1
Segment Length (miles)	8.72	4.55	5	13.14	3.89
Segment #	179-2	89A-3	89A-3	89A-4	89A/260-5
Current # of Lanes (both directions)	2	4	4	4	4
Project Type (one-way or two-way)	two-way	two-way	two-way	two-way	two-way
Additional Lanes (one-way)	1	0	0	0	0
Pro-Rated # of Lanes	2.13	4.00	4.00	4.00	4.00

		Description					
MOBILITY	MOBILITY INDEX	Original Segment Mobility Index	0.830	0.860	0.860	0.480	0.770
		Post-Project # of Lanes (both directions)	2.13	4.00	4.00	4.00	4.00
		Post-Project Segment Mobility Index	0.78	0.780	0.860	0.480	0.700
		Post-Project Segment Mobility Index	0.780	0.780	0.860	0.480	0.700
	FUT V/C	Original Segment Future V/C	1.010	1.080	1.080	0.540	0.900
		Post-Project Segment Future V/C	0.950	0.980	1.080	0.540	0.820
		Post-Project Segment Future V/C	0.950	0.980	1.080	0.540	0.820
	PEAK HOUR V/C	Original Segment Peak Hour V/C (direction 1)	0.570	0.540	0.540	0.340	0.570
		Original Segment Peak Hour V/C (direction 2)	0.560	0.540	0.540	0.330	0.530
		Adjusted total # of Lanes for use in directional peak hr	N/A	N/A	N/A	N/A	N/A
		Post-Project Segement Peak Hr V/C (direction 1)	0.530	0.47	0.54	0.34	0.49
		Post-Project Segement Peak Hr V/C (direction 2)	0.530	0.47	0.54	0.33	0.46
		Post-Project Segment Peak Hr V/C (direction 1)	0.530	0.470	0.540	0.340	0.490
		Post-Project Segment Peak Hr V/C (direction 2)	0.530	0.470	0.540	0.330	0.460
	TTI AND PTI	Safety Reduction Factor	1.000	0.745	0.830	0.675	0.745
		Safety Reduction	0.000	0.255	0.170	0.325	0.255
		Mobility Reduction Factor	0.940	0.907	1.000	1.000	0.909
		Mobility Reduction	0.060	0.093	0.000	0.000	0.091
		Mobility effect on TTI	0.60	0.30	0.30	0.30	0.30
		Mobility effect on PTI	0.50	0.20	0.20	0.20	0.20
		Safety effect on TTI	0.00	0.00	0.00	0.00	0.00
		Safety effect on PTI	0.60	0.30	0.30	0.30	0.30
		Original Directional Segment TTI (direction 1)	1.266	1.295	1.295	1.146	1.301
		Original Directional Segment PTI (direction 1)	3.390	6.966	6.966	3.237	5.289
		Original Directional Segment TTI (direction 2)	1.333	1.239	1.239	1.075	1.267
		Original Directional Segment PTI (direction 2)	4.365	5.547	5.547	1.880	3.017
		Reduction Factor for Segment TTI	0.036	0.028	0.000	0.000	0.027
		Reduction Factor for Segment PTI	0.030	0.095	0.051	0.098	0.095
		Post-Project Directional Segment TTI (direction 1)	1.221	1.259	1.295	1.146	1.265
		Post-Project Directional Segment PTI (direction 1)	3.288	6.303	6.610	2.921	4.789
		Post-Project Directional Segment TTI (direction 2)	1.285	1.204	1.239	1.075	1.232
		Post-Project Directional Segment PTI (direction 2)	4.234	5.019	5.264	1.696	2.732
	CLOSURE EXTENT	Orig Segment Directional Closure Extent (direction 1)	0.089	0.000	0.000	0.538	0.050
		Orig Segment Directional Closure Extent (direction 2)	0.022	0.160	0.160	0.031	0.100
		Segment Closures with fatalities/injuries	5	2	2	12	3
		Total Segment Closures	5	3	3	14	3
		% Closures with Fatality/Injury	1.00	0.67	0.67	0.86	1.00
		Closure Reduction	0.000	0.170	0.113	0.279	0.255
		Closure Reduction Factor	1.000	0.830	0.887	0.721	0.745
		Post-Project Segment Directional Closure Extent (direction 1)	0.089	0.000	0.000	0.388	0.037
		Post-Project Segment Directional Closure Extent (direction 2)	0.022	0.133	0.142	0.022	0.075
	BICYCLE ACCOM	Orig Segment Bicycle Accomodation %	100.0%	71.0%	71.0%	97.0%	29.0%
		Orig Segment Outside Shoulder width	6.1	5.0	5.0	10.0	2.3
		Post-Project Segment Outside Shoulder width	6.1	5.0	5.0	10.0	2.3
		Post-Project Segment Bicycle Accomodation (%)	100.0%	No Change	No Change	No Change	No Change
		Post-Project Segment Bicycle Accomodation (%)	100.0%	No Change	No Change	No Change	No Change
	Needs	Original Segment Mobility Need	2.411	3.349	3.349	0.847	1.878
		Post-Project Segment Mobility Need	1.447	2.024	3.315	0.749	1.626

			Solution #	CS179.1	CS89A.2	CS89A.3	CS89A.3	CS89A/260.4
			Description	SR 179 Hillside Area Mobility and Freight Improvements	West Sedona Area Safety, Mobility, and Freight Improvements	West Sedona Area Safety Improvements	Page Springs Road Intersection Area Safety Improvements	Cottonwood Area Safety and Freight Improvements
LEGEND:			Project Beg MP	313.1	369.64	370.5	356.5	356.5
-user entered value			Project End MP	313.45	374	374	369.64	209.1
-calculated value for reference			Project Length (miles)	0.56	4.36	3.5	13.14	3.89
-calculated value for use in other spreadsheet			Segment Beg MP	304.73	369.64	369	356.5	356.5
-for input into PES spreadsheet			Segment End MP	313.45	374.19	374	369.64	209.1
-assumed values			Segment Length (miles)	8.72	4.55	5	13.14	3.89
			Segment #	179-2	89A-3	89A-3	89A-4	89A/260-5
			Current # of Lanes (both directions)	2	4	4	4	4
Direction 1 = Clockwise (WB 260, NB 89A, SB 179)			Project Type (one-way or two-way)	two-way	two-way	two-way	two-way	two-way
Direction 2 = Counterclockwise (NB 179, SB 89A, EB 260)			Additional Lanes (one-way)	1	0	0	0	0
			Pro-Rated # of Lanes	2.13	4.00	4.00	4.00	4.00
		Description						
FREIGHT	**TTTI AND TPTI**	Mobility effect on TTTI		0.30	0.15	0.15	0.15	0.15
		Mobility effect on TPTI		0.25	0.10	0.10	0.10	0.10
		Safety effect on TTTI		0.00	0.00	0.00	0.00	0.00
		Safety effect on TPTI		0.30	0.15	0.15	0.15	0.15
		Original Directional Segment TTTI (direction 1)		1.477	1.431	1.431	1.283	1.499
		Original Directional Segment TPTI (direction 1)		4.060	6.426	6.426	4.380	9.473
		Original Directional Segment TTTI (direction 2)		1.424	1.333	1.333	1.157	1.402
		Original Directional Segment TPTI (direction 2)		5.973	7.211	7.211	3.140	5.174
		Reduction Factor for Segment TTTI (both directions)		0.018	0.014	0.000	0.000	0.014
		Reduction Factor for Segment TPTI (both directions)		0.015	0.048	0.026	0.049	0.047
		Post-Project Directional Segment TTTI (direction 1)		1.451	1.411	1.431	1.283	1.478
		Post-Project Directional Segment TPTI (direction 1)		3.999	6.120	6.262	4.166	9.025
		Post-Project Directional Segment TTTI (direction 2)		1.398	1.314	1.333	1.157	1.383
		Post-Project Directional Segment TPTI (direction 2)		5.883	6.868	7.027	2.986	4.929
	FREIGHT INDEX	Original Segment TPTI (direction 1)		4.060	6.426	6.426	4.380	9.473
		Original Segment TPTI (direction 2)		5.973	7.211	7.211	3.140	5.174
		Original Segment Freight Index		0.199	0.147	0.147	0.266	0.137
		Post-Project Segment TPTI (direction 1)		3.999	6.120	6.262	4.166	9.025
		Post-Project Segment TPTI (direction 2)		5.883	6.868	7.027	2.986	4.929
		Post-Project Segment Freight Index		0.202	0.154	0.150	0.280	0.143
	CLOSURE DURATION	Orig Segment Directional Closure Duration (dir 1)		21.756	0.000	0.000	145.505	9.900
		Orig Segment Directional Closure Duration (dir 2)		4.178	48.840	48.840	7.400	13.400
		Segment Closures with fatalities		5	2	2	12	3
		Total Segment Closures		5	3	3	14	3
		% Closures with Fatality		1.00	0.67	0.67	0.86	1.00
		Closure Reduction		0.000	0.170	0.113	0.279	0.255
		Closure Reduction Factor		1.000	0.830	0.887	0.721	0.745
		Post-Project Segment Directional Closure Duration (direction 1)		21.756	0.000	0.000	104.918	7.379
		Post-Project Segment Directional Closure Duration (direction 2)		4.178	40.541	43.305	5.336	9.987
	VERT CLR	Original Segment Vertical Clearance		No UP	No UP	No UP	No UP	No UP
		Original vertical clearance for specific bridge		N/A	N/A	N/A	N/A	N/A
		Post-Project vertical clearance for specific bridge		No Change	No Change	No Change	No Change	No Change
		Post-Project Segment Vertical Clearance		No Change	No Change	No Change	No Change	No Change
		Post-Project Segment Vertical Clearance		No Change	No Change	No Change	No Change	No Change
	Needs	Original Segment Freight Need		2.092	2.825	2.825	1.151	2.957
		Post-Project Segment Freight Need		2.055	2.717	2.768	0.838	2.853

LEGEND:
- -user entered value
- -calculated value for reference
- -calculated value for use in other spreadsheet
- -for input into PES spreadsheet
- -assumed values

Direction 1 = Clockwise (WB 260, NB 89A, SB 179)
Direction 2 = Counterclockwise (NB 179, SB 89A, EB 260)

		Solution #	**CS179.1**	**CS89A.2**	**CS89A.3**	**CS89A.3**	**CS89A/260.4**
		Description	SR 179 Hillside Area Mobility and Freight Improvements	West Sedona Area Safety, Mobility, and Freight Improvements	West Sedona Area Safety Improvements	Page Springs Road Intersection Area Safety Improvements	Cottonwood Area Safety and Freight Improvements
		Project Beg MP	313.1	369.64	370.5	356.5	356.5
		Project End MP	313.45	374	374	369.64	209.1
		Project Length (miles)	0.56	4.36	3.5	13.14	3.89
		Segment Beg MP	304.73	369.64	369	356.5	356.5
		Segment End MP	313.45	374.19	374	369.64	209.1
		Segment Length (miles)	8.72	4.55	5	13.14	3.89
		Segment #	179-2	89A-3	89A-3	89A-4	89A/260-5
		Current # of Lanes (both directions)	2	4	4	4	4
		Project Type (one-way or two-way)	two-way	two-way	two-way	two-way	two-way
		Additional Lanes (one-way)	1	0	0	0	0
		Pro-Rated # of Lanes	2.13	4.00	4.00	4.00	4.00
		Description					
BRIDGE	BRIDGE INDEX	Original Segment Bridge Index	No Change	No Change	No Change	No Change	No Change
		Original lowest rating for specific bridge	No Change	No Change	No Change	No Change	No Change
		Post-Project lowest rating for specific bridge	No Change	No Change	No Change	No Change	No Change
		Post-Project lowest rating for specific bridge	No Change	No Change	No Change	No Change	No Change
		Post-Project Segment Bridge Index	No Change	No Change	No Change	No Change	No Change
		Post-Project Segment Bridge Index	No Change	No Change	No Change	No Change	No Change
	SUFF RATING	Original Segment Sufficiency Rating	No Change	No Change	No Change	No Change	No Change
		Original Sufficiency Rating for specific bridge	No Change	No Change	No Change	No Change	No Change
		Post-Project Sufficiency Rating for specific bridge	No Change	No Change	No Change	No Change	No Change
		Post-Project Sufficiency Rating for specific bridge	No Change	No Change	No Change	No Change	No Change
		Post-Project Segment Sufficiency Rating	No Change	No Change	No Change	No Change	No Change
		Post-Project Segment Sufficiency Rating	No Change	No Change	No Change	No Change	No Change
	BR RTNG	Original Segment Bridge Rating	No Change	No Change	No Change	No Change	No Change
		Post-Project Segment Bridge Rating	No Change	No Change	No Change	No Change	No Change
		Post-Project Segment Bridge Rating	No Change	No Change	No Change	No Change	No Change
	% FUN OB	Original Segment % Functionally Obsolete	No Change	No Change	No Change	No Change	No Change
		Post-Project Segment % Functionally Obsolete	No Change	No Change	No Change	No Change	No Change
		Post-Project Segment % Functionally Obsolete	No Change	No Change	No Change	No Change	No Change
	Needs	Original Segment Bridge Need	No Change	No Change	No Change	No Change	No Change
		Post-Project Segment Bridge Need	No Change	No Change	No Change	No Change	No Change
PAVEMENT	PAVEMENT INDEX	Original Segment Pavement Index	3.306	No Change	No Change	No Change	No Change
		Original Segment IRI in project limits	162.59	No Change	No Change	No Change	No Change
		Original Segment Cracking in project limits	0.1	No Change	No Change	No Change	No Change
		Post-Project IRI in project limits	45	No Change	No Change	No Change	No Change
		Post-Project IRI in project limits	45	No Change	No Change	No Change	No Change
		Post-Project Cracking in project limits	0.1	No Change	No Change	No Change	No Change
		Post-Project Cracking in project limits	0.1	No Change	No Change	No Change	No Change
		Post-Project Segment Pavement Index	3.548	No Change	No Change	No Change	No Change
		Post-Project Segment Pavement Index	3.548	No Change	No Change	No Change	No Change
	DIRECTION PSR	Original Segment Directional PSR (direction 1)	3.280	No Change	No Change	No Change	No Change
		Original Segment Directional PSR (direction 2)	3.331	No Change	No Change	No Change	No Change
		Original Segment IRI in project limits	162.59	No Change	No Change	No Change	No Change
		Post-Project directional IRI in project limits	45	No Change	No Change	No Change	No Change
		Post-Project Segment Directional PSR (direction 1)	3.584	No Change	No Change	No Change	No Change
		Post-Project Segment Directional PSR (direction 2)	3.512	No Change	No Change	No Change	No Change
		Post-Project Segment Directional PSR (direction 1)	3.584	No Change	No Change	No Change	No Change
		Post-Project Segment Directional PSR (direction 2)	3.512	No Change	No Change	No Change	No Change
	% FAIL	Original Segment % Failure	27.8%	No Change	No Change	No Change	No Change
		Post-Project Segment % Failure	15.0%	No Change	No Change	No Change	No Change
		Post-Project Segment % Failure	15.0%	No Change	No Change	No Change	No Change
	Needs	Original Segment Pavement Need	1.143	No Change	No Change	No Change	No Change
		Post-Project Segment Pavement Need	0.300	No Change	No Change	No Change	No Change

CMF Application

SR 179/SR 89A/SR 260 Corridor Profile Study
CMF Application

=user input

CS89A.2 (MP 270-374)

BMP	EMP	CMF1	CMF2	CMF3	CMF4	CMF5	Dir	Effective CMF	Crashes in Segment Limits Fatal	Crashes in Segment Limits Incap	Crashes in Solution Limits Fatal	Crashes in Solution Limits Incap	Post-Solution Crashes Fatal	Post-Solution Crashes Incap	Crash Reduction Fatal	Crash Reduction Incap
369.6	370.5	0.81	0.90	1	1	1	NB/WB - Clockwise	0.770			0	0	0.000	0.000	0.000	0.000
369.6	370.5	0.81	0.90	1	1	1	SB/EB - Counter Clockwise	0.770			0	0	0.000	0.000	0.000	0.000
370.5	373.1	0.81	0.83	0.90	1	1	NB/WB - Clockwise	0.704			0	2	0.000	1.408	0.000	0.592
370.5	373.1	0.81	0.83	0.90	1	1	SB/EB - Counter Clockwise	0.704			2	1	1.408	0.704	0.592	0.296
373.1	374	0.83	1	1	1	1	NB/WB - Clockwise	0.830			0	0	0.000	0.000	0.000	0.000
373.1	374	0.83	1	1	1	1	SB/EB - Counter Clockwise	0.830			1	1	0.830	0.830	0.170	0.170
							NB/WB - Clockwise		0	2	0	2	**0.000**	**1.408**	0.000	0.592
							SB/EB - Counter Clockwise		3	2	3	2	**2.238**	**1.534**	0.762	0.466

CS89A.3 (MP 356-369)

BMP	EMP	CMF1	CMF2	CMF3	CMF4	CMF5	Dir	Effective CMF	Crashes in Segment Limits Fatal	Crashes in Segment Limits Incap	Crashes in Solution Limits Fatal	Crashes in Solution Limits Incap	Post-Solution Crashes Fatal	Post-Solution Crashes Incap	Crash Reduction Fatal	Crash Reduction Incap
362.5 (Page Springs Road)		0.76	1	1	1	1	NB/WB - Clockwise	0.760			0	0	0.000	0.000	0.000	0.000
362.5 (Page Springs Road)		0.76	1	1	1	1	SB/EB - Counter Clockwise	0.760			1	0	0.760	0.000	0.240	0.000
366 curve		0.76	0.79	0.83	1	1	NB/WB - Clockwise	0.622			2	0	1.245	0.000	0.755	0.000
366 curve		0.76	0.79	0.83	1	1	SB/EB - Counter Clockwise	0.622			1	0	0.622	0.000	0.378	0.000
368.4 curves		0.75	0.76	0.79	1	1	NB/WB - Clockwise	0.591			0	1	0.000	0.591	0.000	0.409
368.4 curves		0.75	0.76	0.79	1	1	SB/EB - Counter Clockwise	0.591			2	5	1.181	2.954	0.819	2.047
356	369	0.76	1	1	1	1	NB/WB - Clockwise	0.760			0	3	0.000	2.280	0.000	0.720
356	369	0.76	1	1	1	1	SB/EB - Counter Clockwise	0.760			3	0	2.280	0.000	0.720	0.000
							NB/WB - Clockwise		2	4	2	4	**1.245**	**2.871**	0.755	1.129
							SB/EB - Counter Clockwise		7	5	7	5	**4.844**	**2.954**	2.156	2.047

CS89A/260.4 (MP 356-209)

BMP	EMP	CMF1	CMF2	CMF3	CMF4	CMF5	Dir	Effective CMF	Crashes in Segment Limits Fatal	Crashes in Segment Limits Incap	Crashes in Solution Limits Fatal	Crashes in Solution Limits Incap	Post-Solution Crashes Fatal	Post-Solution Crashes Incap	'otal Crash Reductio Fatal	'otal Crash Reductio Incap
356 on 89A	209 on 260	0.81	0.90	1	1	1	EB Counter Clockwise	0.770			0	1	0.000	0.770	0.000	0.231
356 on 89A	209 on 260	0.81	0.90	1	1	1	WB - Clockwise	0.770			3	4	2.309	3.078	0.692	0.922
207.2 (Rio Mesa Trail)		0.75	0.81	0.83	0.9	1	EB Counter Clockwise	0.590			0	1	0.000	0.590	0.000	0.410
207.2 (Rio Mesa Trail)		0.75	0.81	0.83	0.9	1	WB - Clockwise	0.590			0	1	0.000	0.590	0.000	0.410
208.8 (Western Dr)		0.81	0.83	0.85	0.90	1	EB Counter Clockwise	0.651			0	0	0.000	0.000	0.000	0.000
208.8 (Western Dr)		0.81	0.83	0.85	0.90	1	WB - Clockwise	0.651			0	2	0.000	1.303	0.000	0.697
208	209	0.81	0.83	0.90	1	1	EB Counter Clockwise	0.704			0	1	0.000	0.704	0.000	0.296
208	209	0.81	0.83	0.90	1	1	WB - Clockwise	0.704			1	1	0.704	0.704	0.296	0.296
							EB Counter Clockwise		0	3	0	3	**0.000**	**2.064**	0.000	0.936
							WB - Clockwise		4	8	4	8	**3.013**	**5.675**	0.987	2.325

Performance Area Scoring

				Pavement					Bridge					Safety					Mobility					Freight					
Candidate Solution #	Candidate Solution Name	Milepost Location	Estimated Cost ($ millions)	Existing Segment Need	Post-Solution Segment Need	Raw Score	Risk Factor	Factored Score	Existing Segment Need	Post-Solution Segment Need	Raw Score	Risk Factor	Factored Score	Existing Segment Need	Post-Solution Segment Need	Raw Score	Risk Factor	Factored Score	Existing Segment Need	Post-Solution Segment Need	Raw Score	Risk Factor	Factored Score	Existing Segment Need	Post-Solution Segment Need	Raw Score	Risk Factor	Factored Score	Total Risk Factored Performance Area Benefit
CS179.1	SR 179 Hillside Area Mobility and Freight Improvements	313-314	8.89	1.143	0.300	0.843	2.10	1.770	0.000	0.000	0.000	0.00	0.000	0.616	0.616	0.000	5.21	0.000	2.411	1.447	0.964	7.38	7.112	2.092	2.055	0.037	6.66	0.248	9.131
CS89A.2	West Sedona Area Safety, Mobility, and Freight Improvements	370-374	4.86	0.010	0.010	0.000	0.00	0.000	0.000	0.000	0.000	0.00	0.000	3.792	2.148	1.644	5.31	8.733	3.349	2.024	1.325	6.07	8.046	2.825	2.717	0.108	5.11	0.552	17.331
CS89A.3	Page Springs Road Intersection Area Safey Improvements	356-369	7.95	0.000	0.000	0.000	0.00	0.000	1.789	1.789	0.000	0.00	0.000	5.832	3.341	2.491	3.13	7.807	0.847	0.749	0.098	3.67	0.358	1.151	0.838	0.313	3.96	1.238	9.403
CS89A/ 260.4	Cottonwood Area Safety and Freight Improvements	356-209	3.06	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.00	0.000	6.501	4.363	2.138	5.15	11.016	1.878	1.626	0.252	2.85	0.719	2.957	2.853	0.104	2.94	0.305	12.041

Performance Effectiveness Scoring

				Safety Emphasis Area						Pavement Emphasis Area						Mobility Emphasis Area									
Candidate Solution #	Candidate Solution Name	Milepost Location	Estimated Cost ($ millions)	Existing Corridor Need	Post-Solution Corridor Need	Raw Score	Risk Factor	Emphasis Factor	Factored Score	Existing Corridor Need	Post-Solution Corridor Need	Raw Score	Risk Factor	Emphasis Factor	Factored Score	Existing Corridor Need	Post-Solution Corridor Need	Raw Score	Risk Factor	Emphasis Factor	Factored Score	Total Factored Benefit	VMT Factor	NPV Factor	Performance Effectiveness Score
CS179.1	SR 179 Hillside Area Mobility and Freight Improvements	313-314	8.89	3.685	3.685	0.000	5.21	1.50	0.000	1.184	0.777	0.406	2.10	1.50	1.280	2.030	1.954	0.076	7.38	1.50	0.843	11.254	2.77	20.2	70.8
CS89A.2	West Sedona Area Safety, Mobility, and Freight Improvements	370-374	4.86	3.685	3.574	0.111	5.31	1.50	0.884	1.184	1.184	0.000	0.00	1.50	0.000	2.030	1.967	0.062	6.07	1.50	0.568	18.783	3.30	20.2	257.8
CS89A.3	Page Springs Road Intersection Area Safey Improvements	356-369	7.95	3.685	3.076	0.609	3.13	1.50	2.864	1.184	1.184	0.000	0.00	1.50	0.000	2.030	2.030	0.000	3.67	1.50	0.000	12.267	1.23	15.3	29.0
CS89A/ 260.4	Cottonwood Area Safety and Freight Improvements	356-209	3.06	3.685	3.531	0.154	5.15	1.50	1.187	1.184	1.184	0.000	0.00	1.50	0.000	2.030	1.983	0.047	2.85	1.50	0.200	13.427	3.50	15.3	235.1

miles	2015 ADT	1-way or 2-way	VMT
3.50	16604	2	58112
3.50	22225	2	77788
1.45	13965	2	20249
3.89	22244	2	86529

Appendix J: Solution Prioritization Scores

Candidate Solution #	Candidate Solution Name	Milepost Location	Estimated Cost ($ millions)	Pavement		Bridge		Safety		Mobility		Freight		Total Factored Score	Risk Factors					Weighted Risk Factor	Segment Need	Prioritization Score
				Score	%	Score	%	Score	%	Score	%	Score	%		Pavement	Bridge	Safety	Mobility	Freight			
CS179.1	SR 179 Hillside Area Mobility and Freight Improvements	313-314	8.89	3.050	27.1%	0.000	0.0%	0.000	0.0%	7.955	70.7%	0.248	2.2%	11.254	1.14	1.51	1.78	1.36	1.36	1.300	1.46	**135**
CS89A.2	West Sedona Area Safety, Mobility, and Freight Improvements	370-374	4.86	0.000	0.0%	0.000	0.0%	9.617	51.2%	8.613	45.9%	0.552	2.9%	18.783	1.14	1.51	1.78	1.36	1.36	1.575	1.85	**750**
CS89A.3	Page Springs Road Intersection Area Safey Improvements	356-369	7.95	0.000	0.0%	0.000	0.0%	10.671	87.0%	0.358	2.9%	1.238	10.1%	12.267	1.14	1.51	1.78	1.36	1.36	1.725	1.38	**69**
CS89A/ 260.4	Cottonwood Area Safety and Freight Improvements	356-209	3.06	0.000	0.0%	0.000	0.0%	12.203	90.9%	0.919	6.8%	0.305	2.3%	13.427	1.14	1.51	1.78	1.36	1.36	1.742	1.38	**567**

Appendix K: Preliminary Scoping Reports for Prioritized Solutions

Appendix K will be provided in the Draft Final Report